RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1934. **[May**

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1933. BY L. L. FERMOR, O.B.E. D.Sc., A.R.S.M., F.R.S., F.G.S., F.A.S.B., M.I.M.M., *Director, Geological Survey of India.*

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DISPOSITION LIST.

DURING the period under report the officers of the Department were employed as follows:—

Superintendents.

DR. G. DE P. COTTER	Retired from service from the 28th August, 1933.
DR. J. COGGIN BROWN	On leave preparatory to retirement.
MR. H. C. JONES	Retired from service from the 25th June, 1933.
DR. A. M. HERON	Granted leave out of India on average pay for 6 months; availed himself of the same with effect from the 27th March, 1933, from the field, and returned from leave and resumed duty on the 22nd September, 1933. Appointed to officiate as Director from the 5th October to the 22nd December, 1933, and placed in charge of the Northern Circle after that period. Remained at headquarters.

Superintendents—contd.

DR. C. S. FOX . . Returned from the field on the 30th March, 1933. Placed in charge of the Southern Circle till the 26th March, 1933, and thereafter in charge of the Northern Circle till the 22nd December, 1933. Deputed from the 30th October to the 26th November, 1933, to examine the site selected for the construction of a dam on the Bhavani river in the Coimbatore district, and to investigate the occurrences of the laterite in South India. Left for Assam on the 18th December, 1933, and placed in charge of the Southern Circle.

MR. E. L. G. CLEGG . Continued in charge of the Burma Circle. Returned from field work in the Mogok area to Rangoon on the 16th May, 1933. Proceeded to Taikkyi on the 20th May, 1933, in connection with the geological examination of the Gyobyu and Nyaunglebin Lakes Scheme, and returned to Rangoon on the 22nd May, 1933. Continued the large scale geological survey of the Mogok Stone Tract and left for the field on the 2nd November, 1933.

Assistant Superintendents.

MR. H. CROOKSHANK . Returned from the field on the 15th May, 1933. Appointed to officiate as Superintendent from the 27th March to the 21st September, 1933, and again from the 5th October to the 22nd December, 1933. Placed in charge of the Southern Circle till the 22nd December, 1933, and left for the field in the Central Provinces on the 10th November, 1933.

Assistant Superintendents—contd.

MR. G. V. HOBSON .	On leave preparatory to retirement.
RAO BAHADUR M. VINAYAK RAO . .	Retired from service from the 14th February, 1933.
MR. E. J. BRADSHAW	Returned from field work in Assam on the 12th March, 1933. Attached to the Burma Circle and assumed charge of the duties of the Resident Geologist and Official Member, Yenangyaung and Singu Oilfield Advisory Boards at Yenangyaung on the 20th March, 1933.
DR. A. L. COULSON	Remained at headquarters in charge of Office as Assistant Director.
MR. D. N. WADIA	Remained at headquarters as Palæontologist. Granted leave on average pay from the 11th to the 22nd December, 1933, with permission to affix the Christmas holidays.
DR. J. A. DUNN .	Returned from the field on the 17th May, 1933. Attached to the Southern Circle and left for the field in Bihar and Orissa on the 23rd October, 1933.
MR. C. T. BARBER	Continued as Resident Geologist at Yenangyaung till the 13th March, 1933. Granted leave on average pay for 8 months combined with leave on half average pay for 20 months, preparatory to retirement, from the 17th March, 1933.

Assistant Superintendents—contd.

MR. E. R. GEE . .	Returned from the field on the 14th June, 1933. Attached to the Northern Circle and left for the Salt Range, Punjab, on the 6th October, 1933.
MR. W. D. WEST	Continued to act as Curator of the Geological Museum and Laboratory till the 20th April, 1933. Granted leave out of India on average pay for 6 months and 23 days from the 21st April, 1933. Returned from leave and resumed duty on the 11th November, 1933. Attached to the Southern and Northern Circles for work in the Central Provinces and the Himalaya respectively and left for field work in the Nagpur district on the 27th December, 1933.
DR. M. S. KRISHNAN	Returned from the field on the 19th April, 1933. Appointed Curator of the Geological Museum and Laboratory from the 21st April, 1933.
MR. P. LEICESTER	Retired from service from the 7th May, 1933.
DR. S. K. CHATTERJEE	Retired from service from the 30th August, 1933.
MR. J. B. AUDEN .	Returned from the field on the 9th May, 1933. Granted leave on average pay for 6 months and 8 days combined with study leave for 1 month and 10 days from the 31st May, 1933. Attached to the Northern Circle for continuing his work in the Outer Himalayas on return from leave.

Assistant Superintendents—concld.

MR. V. P. SONDHI	. Granted leave on average pay from the 12th to the 31st January and from the 5th to the 20th February, 1933, from the field in the Southern Shan States. Deputed to examine the Gyobyu and Nyaunglebin Lakes Scheme of the Rangoon Corporation from the 5th to the 22nd May, 1933. Returned to the field on the 28th May, 1933, and arrived back in Rangoon for recess on the 4th July, 1933. Attached to the Burma Circle to continue his work in the Southern Shan States and left for the field on the 3rd November, 1933.
MR. B. B. GUPTA	. Retired from service from the 1st November, 1933.

Extra Assistant Superintendents.

DR. H. L. CHHIBBER	Granted extension of leave out of India on half average pay for 2 months and 14 days and leave without allowance for 12 days in continuation of study leave for 7 months, from the 2nd March, 1933.
DR. P. K. GHOSH	Returned from the field on the 7th April, 1933. Attached to the Southern Circle for work in the Central Provinces and left for the field on the 17th November, 1933.
DR. M. R. SAHNI	Returned to Rangoon for recess on the 13th June, 1933. Attached to the Burma Circle to continue his work in the Northern Shan States and left for the field on the 3rd November, 1933.

Extra Assistant Superintendents—contd.

MR. D. BHATTACHARJI .	Returned from the field on the 2nd May, 1933. Granted leave on average pay for 1 month and 10 days from the 13th November, 1933, with permission to affix the Christmas holidays. Attached to the Southern Circle to continue his work in the Bhandara district.
MR. B. C. GUPTA	Returned from the field on the 3rd May, 1933. Attached to the Northern Circle for work in Bombay Presidency and left for the field on the 20th November, 1933.
MR. H. M. LAHIRI	Returned from the field on the 4th May, 1933. Attached to the Northern Circle to continue his work in the Hoshiarpur and Kangra districts and left for the field on the 8th November, 1933.
DR. L. A. NARAYANA IYER	Returned from the field to Rangoon for recess on the 8th May, 1933. Granted leave on average pay from the 12th May to the 4th June, 1933. Attached to the Burma Circle to continue his work in the Mogok Stone Tract and left for the field on the 5th November, 1933.
MR. P. N. MUKERJEE	Returned from the field on the 3rd May, 1933. Granted leave on average pay from the 12th to the 31st July, 1933. Attached to the Northern Circle for work in Bombay Presidency and left for the field on the 14th November, 1933.

Extra Assistant Superintendents—concld.

DR. A. K. DEY .	Returned from the field on the 12th April, 1933, again left for the field on the 3rd May and returned on the 24th May, 1933. Attached to the Southern Circle and left for the field in Bihar and Orissa on the 20th November, 1933.
MR. AUSTIN M. N. GHOSH . .	Returned from the field on the 19th April, 1933. Confirmed in the grade of Extra Assistant Superintendent from the 15th March, 1933. Attached to the Northern and Southern Circles for work in the Punjab Salt Range and in Assam respectively, and left for the field on the 21st October, 1933. Returned from the Punjab on the 31st December, 1933.

Artist.

MR. K. F. WATKINSON .	On leave preparatory to retirement.

Assistant Curator.

P. C. ROY	At headquarters. Granted leave on average pay from the 4th January to the 4th March, 1933.

Field Collectors.

N. K. N. AIYENGAR	At headquarters. Granted leave on average pay from the 3rd May to the 21st June, 1933. Attached to the Northern Circle and left for the field on the 31st December, 1933.

Field Collectors—contd.

A. B. DUTT . . At headquarters. Promoted to the post of Field Collector on probation for one year from the 15th March, 1933. Granted leave on average pay from the 1st to the 31st May, 1933. Attached to the Southern Circle for work under Dr. J. A. Dunn in Bihar and Orissa and left for the field on the 25th October, 1933.

Assistant Chemist.

MAHADEO RAM . At headquarters. Granted leave on average pay from the 10th to the 30th April, 1933.

Museum Assistants.

D. GUPTA . At headquarters. Granted leave on average pay from the 8th November to the 22nd December, 1933, with permission to affix the Christmas holidays.

M. S. VENKATRAM Appointed as Museum Assistant substantively on probation for one year from the 15th March, 1933. Granted leave on average pay from the 5th to the 31st October, 1933, with permission to prefix the Puja holidays. At headquarters.

Temporary Museum Assistant.

V. BHASKARA RAO . Appointed as Temporary Museum Assistant from the 3rd July, 1933, subject to the production of a medical certificate of health.

2. The cadre of the Department consisted of 3 Superintendents and 10 Assistant Superintendents.

ADMINISTRATIVE CHANGES.

3. Dr. A. M. Heron officiated as Director from the 5th October to the 22nd December, 1933, *vice* Dr. L. L. Fermor on leave.

Promotions and appointments.

Mr. H. Crookshank officiated as Superintendent from the 27th March to the 21st September, 1933, *vice* Dr. A. M. Heron on leave, and again from the 5th October to the 22nd December, 1933, *vice* Dr. A. M. Heron officiating as Director.

Mr. W. D. West acted as Curator of the Geological Museum and Laboratory up to the 20th April, 1933, and thereafter Dr. M. S. Krishnan.

Mr. A. M. N. Ghosh was confirmed in the grade of Extra Assistant Superintendent with effect from the 15th March, 1933.

Retirement.

4. Dr. G. de P. Cotter, Superintendent, retired from the service with effect from the 28th August, 1933.

Mr. H. C. Jones, Superintendent, retired from the service with effect from the 25th June, 1933.

Rao Bahadur M. Vinayak Rao, Assistant Superintendent, retired from the service with effect from the 14th February, 1933.

Mr. P. Leicester, Assistant Superintendent, retired from the service with effect from the 7th May, 1933.

Dr. S. K. Chatterjee, Assistant Superintendent, retired from the service with effect from the 30th August, 1933.

Mr. B. B. Gupta, Assistant Superintendent, retired from the service with effect from the 1st November, 1933.

Leave.

5. Dr. L. L. Fermor was granted combined leave out of India for two months and nineteen days with effect from the 5th October, 1933, with permission to prefix the Puja holidays and to affix the Christmas holidays.

Dr. A. M. Heron was granted leave out of India on average pay for six months with effect from the 27th March, 1933.

Mr. D. N. Wadia was granted leave on average pay for twelve days with effect from the 11th December, 1933, with permission to affix the Christmas holidays.

Mr. C. T. Barber was granted combined leave for two years and four months with effect from the 17th March, 1933.

Mr. W. D. West was granted leave out of India on average pay for six months and twenty-three days with effect from the 21st April, 1933.

Mr. J. B. Auden was granted combined leave for seven months and eighteen days with effect from the 31st May, 1933.

Mr. V. P. Sondhi was granted leave on average pay for twenty days with effect from the 12th January, 1933, and again for sixteen days with effect from the 5th February, 1933.

Dr. H. L. Chhibber was granted extension of leave out of India on half average pay for two months and fourteen days and leave without allowance for twelve days in continuation of study leave for seven months with effect from the 2nd March, 1933.

Mr. D. Bhattacharji was granted leave on average pay for one month and ten days with effect from the 13th November, 1933, with permission to affix the Christmas holidays.

Dr. L. A. Narayana Iyer was granted leave on average pay for twenty-nine days with effect from the 12th May, 1933.

Mr. P. N. Mukerjee was granted leave on average pay for twenty-one days with effect from the 12th July, 1933.

LECTURESHIP.

6. Mr. W. D. West continued to act as a part-time Professor of Geology at the Presidency College, Calcutta, up to the 20th April, 1933, thereafter Dr. M. S. Krishnan from the 24th July, 1933.

POPULAR LECTURES.

7. Two popular lectures were given during the year by Mr. A. M. N. Ghosh, arising out of his work with Dr. C. A. Matley on the dinosaurs near Jubbulpore. The first was 'On the making of Jubbulpore' and was delivered before the Central Provinces and Berar Geographical Association, Jubbulpore: the second was on 'Some Prehistoric Reptiles of India', and was delivered before the Bengal Women's Education League, Calcutta.

PUBLICATIONS.

8. The following publications were issued during the year under report:—

1. Records, Vol. LXVI, Part 4.
2. Records, Vol. LXVII, Part 1.
3. Records, Vol. LXVII, Part 2.
4. Records, Vol. LXVII, Part 3.

5. Memoirs, Vol. XVIII, Part 1 (Reprint).
6. Memoirs, Vol. XXI, Part 2 (Reprint).
7. Memoirs, Vol. XXI, Part 4 (Reprint).
8. Memoirs, Vol. LV, Part 2.
9. Memoirs, Vol. LXII, Part 1.
10. Memoirs, Vol. LXII, Part 2.
11. Memoirs, Vol. LXIII, Part 1.
12. Memoirs, Vol. LXIV, Part 1.
13. Palæontologia Indica, New Series, Vol. IX, Memoir No. 2, Part VI.
14. Palæontologia Indica, New Series, Vol. XXI, Memoir No. 1.
15. Palæontologia Indica, New Series, Vol. XXII, Memoir No. 1.

LIBRARY.

9. The additions to the library amounted to 3,278 volumes, of which 1,055 were acquired by purchase and 2,223 by presentation and exchange.

DRAWING OFFICE.

10. The Artist, Mr. K. F. Watkinson, was on leave preparatory to retirement, and Mr. S. Ray held charge of the Drawing Office throughout the year.

Publications.

11. During the year, 135 half-tone and line blocks were prepared for plates of the Records, Memoirs and Palæontologia Indica, and 80 plates were printed off. 55 drawings and 52 line blocks for text figures, were also prepared.

The number of geologically coloured originals received from officers totalled 165, while 2,449 topographical sheets were received from the Director, Map Publication, Survey of India, and 555 were issued for departmental use.

Photographic Section.

12. This department was fully occupied with copying, developing and printing work for publications and reports. The number of negatives received into stock totalled 239, while 1,534 photographic prints were made. In addition, 105 lantern slides were prepared.

MUSEUM AND LABORATORY.

13. Mr. W. D. West continued as Curator of the Geological Museum and Laboratory till the 20th April, 1933, when he proceeded on leave and was replaced by Dr. M. S. Krishnan.

Staff.

Babu Purna Chandra Roy, Assistant Curator, was on leave from the 4th January to the 4th March. Babus Dasarathi Gupta and Anil Bhusan Dutt continued as Museum Assistants, but the latter was promoted to the post of Field Collector from the 15th March. M. R. Ry. M. S. Venkatram continued to work as temporary Museum Assistant until 15th March, when he was appointed substantively *vice* Babu Anil Bhusan Dutt promoted to the Field Collector's grade. M. R. Ry. V. Bhaskara Rao was appointed as temporary Museum Assistant from the 3rd July.

Chemical work.

14. The Department is now without a Chemist, though there has been no diminution in the amount of work in the laboratory, following the reduction in the personnel carried out recently as a measure of retrenchment. As a result, a considerable amount of analytical work has had to be done by the Assistant Curator, at the cost of interference with his routine duties in the Laboratory and Museum. In addition, a limited number of analyses have been made abroad. The need for a chemist is, in fact, very keenly felt, and it is hoped that Government will take up the question of appointing one at a very early date.

Instruments.

15. The transfer of the charge of the field instruments from the Artist to the Curator has necessitated a considerable amount of labour on the part of both Mr. West and Dr. Krishnan, in rearranging and renumbering. The work of the Curator has steadily been increasing during the last few years, so that at present his time is fully occupied with the routine duties connected with the post, leaving him no time for chemical work to reduce the inconvenience earned by the loss of our Chemist.

Determinative work.

16. During the year, the number of specimens referred to the Curator for examination and report was 530, and assays, quantitative analyses or other special determinations were made of 50 of these. The corresponding figures for 1932 were 385 and 44 respectively. The quantitative work included assays of ores of copper, silver, gold, chromium, iron and vanadium, and analyses of bauxite, cement slags, limestone, dolerite and coal and special tests of clays, sands and ochres.

Donations to institutions, etc.

17. Presentations of Indian rocks and minerals were made to the following institutions during the year under review :—

1. The Sedgwick Museum, Cambridge, England, through Dr. A. Harker.
2. The Secondary Training College, Bombay.
3. The Department of Chemistry, Aligarh University.
4. The private school of Mrs. S. A. Sarabhai, Sahibag, Ahmedabad.
5. The Forest Museum, Hinoo, Ranchi.
6. The East Indian Railway High English School, Asansol.
7. The Baidyashastra Pith, Calcutta.
8. The Geological Survey of Tanganyika, Dodoma, East Africa.
9. The Bengal Engineering College, Sibpur, Howrah.
10. The Raipur Museum, Raipur, Central Provinces.
11. The Department of Applied Chemistry, University College of Science, Calcutta.
12. The School of Higher Commercial Studies, Montreal, Canada.

In two cases among the above (Nos. 4 and 12), the specimens were supplied at a nominal charge. In addition, the following specific representations were made :—

1. Beryl crystals, to Bergassessor Dr. E. Köhl, Preuss. Geolog. Landesanstalt, Berlin.
2. Beryl crystals from various Indian occurrences, to Lord Rayleigh, London.
3. Volcanic ash, to Messrs. Francois Cementation Co., Ltd., Poona.
4. Corundum crystals, to W. H. Bates, Esq., Burn & Co.'s Pottery Works, Raniganj.
5. Specimens of laterite, to Prof. Hermann Harassowitz, University of Giessen, Germany.
6. Samples of Indian coal, to Prof. J. W. Cobb, University of Leeds, England.
7. Samples of Indian coal, to the Low Temperature Carbonisation, Ltd., London, England.
8. Specimens of lignitic coal, to Sir C. V. Raman, Indian Association for the Cultivation of Science, Calcutta.
9. Specimens of coal, to A. K. Banerji, Esq., Bengal Engineering College, Sibpore.

Additions to collections of the Department.

18. The officers of the Department collected, as usual, a large number of specimens in the course of their work. Among these particular mention may be made of a fine beryl crystal measuring ten inches along the vertical axis and eight inches across, and weighing 48 lbs., collected by Dr. P. K. Ghosh from the L. N. mica mine, Nellore; and stalactites of rock-salt from the salt mines at Khewra and Warcha, Punjab, by Dr. L. L. Fermor. In addition, the following Indian specimens were received and incorporated in the collections of the Geological Survey of India:—

1. Refractory bricks (firebrick, chrome, magnesite, lisil and claysil), presented by Messrs. Burn & Co.
2. Allanite from Kurinjakulam, Tinnevelly district, Madras, presented by Mr. V. S. Sambasiva Iyer.
3. Vanadiferous iron-ore, from Dalma Hill, Singhbhum, presented by the Bihar Mining Corporation.
4. Beryl from Vadesamudra near Bangalore, presented by the Mysore Geological Department.
5. Silica brick converted into tridymite, presented by Dr. E. Spencer.
6. Ornamental objects made of salt, from Kalabagh, Punjab, presented by Mr. E. R. Gee.
7. Transparent barytes, from Balpalapalle mine, Kurnool district, Madras, presented by M. R. Ry. B. P. Sesha Reddy Garu.
8. Fuchsite-quartzite from Easwarahalli, Kadur district, Mysore, presented through the Hon'ble the Political Resident in Mysore.
9. Sheared coal from Sisneri Khola, Nepal, presented by Mr. H. M. Sale.
10. Alunogen from Cuddapah district, Madras, presented by the Director of Industries, Madras.
11. Graphite from Pedakonda, East Godavari district, presented by the Collector of East Godavari.

A fine collection of geodic minerals, zeolites and calcite mostly, from the Deccan trap at Bombay, was purchased from Mr. J. Ribeiro, and added to the collections. The following foreign specimens were also acquired:—

1. Cassiterite from Mwirasando tin-field, Uganda, presented by Miss J. H. Robertson.

2. Quartz crystal from Tibet, presented by Mr. J. Van Manen.
3. Tourmaline crystal from Tibet, presented by Mr. Dhanbir Singh Khattri.
4. Eight specimens, consisting of manganese-ore, associated sandstone and the underlying decomposed granite, from Nicopol, Republic of Georgia, U. S. S. R., by exchange with Professor Loewinson-Lessing, Leningrad.
5. Malachite from Kambove mine, Belgian Congo, and chrysotile asbestos from Gaths mine, Mashaba, Southern Rhodesia, from the private collections of the late Sir Henry Hayden, through the courtesy of Mr. A. A. Vlasto.

Rangoon Office.

19. In the Laboratory of the Rangoon office Mr. L. R. Sharma continued his duties as Chemical Assistant to the Burma Circle. Up to the end of October, 1933, 78 specimens were received and reported upon, out of which 34 were quantitatively determined. The specimens examined included a variety of rocks from Mogok, sands and clays from the Pegu Yomas, limestones, lead-ores and reputed gold-ores from the Shan States and reputed gold-ores from the Katha district.

PETROLOGY.

Pavagad Hill, Panch Mahals, Bombay Presidency.

20. As a result of a hasty visit to Pavagad Hill in 1905 whilst examining the manganese-ore deposits of the Panch Mahals, I contributed a paper on the lavas constituting this hill, describing them in agreement with the view that this block, first visited by W. T. Blanford, was an outlier of the Deccan Trap formation.[1] Some two or three years ago, however, the view was advanced that this hill marks the site of a volcano of the central type and that the summit rhyolite is the core marking the central vent of the volcano.[2] Accordingly I asked Dr. Heron specially to re-examine Pavagad Hill with this possibility in view, when an opportunity should arise in the course of his inspection duties.

Accordingly, besides examining the rocks of the Champaner series (see page 25) in North Bombay, Dr. Heron also re-examined

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 148-166, (1906).

[2] This view has found expression in a paper by Mr. V. S. Dubey read before the Indian Science Congress at Poona this January (1934). and also in Professor K. K. Mathru's Presidential Address to the geological section of the Congress.

Pavagad Hill. Dr. Heron reports that Pavagad Hill is an outlier of Deccan trap, exposing a thickness of over two thousand feet of basalt flows, resting on a platform of 'Nimar sandstone' (Bagh beds), which in its turn lies unconformably on Aravalli (formerly called 'Champaner series') phyllites. The basalts and the sandstone have a gentle northerly inclination, so that the sandstone appears only at the southern base. The basalts are capped by a single flow of rhyolite, which is considerably thicker than any of the basalts. The abundant blocks of rhyolite, often of great size, which strew the gentler slopes, are all derived from this, the only rhyolite. Its base is well exposed, resting horizontally upon a few feet of soft, earthy red rock, which may either be tuff, or 'moorum' (decomposed trap) representing an old land-surface. This has in places been caved from below the rhyolite, exposing the horizontal base of the latter for some feet in, and proving that it is not a plug. Downwards this red rock passes into more coherent, but still soft, green rock. Additional proofs are in the horizontal fluxion structure, and the vertical jointing of the rhyolite, which starts from both upper and lower surfaces, and divides the flow into rude vertical monoliths. This jointing is not continuous from top to bottom, but leaves a central portion in which the jointing is sparser and less regular. The position of the rhyolite, resting on a much more easily eroded layer, has made it liable to *denudation,* but it is extremely resistant against *decomposition.* The hard angular blocks strewing the base of the hill show a little differential erosion of the fluxion layers, but the rock is very resistant to atmospheric weathering, and it is the joints, and not the fluxion layers, along which it breaks up. The presence of the rhyolite is the factor which has preserved this isolated outlier from removal.

PALÆONTOLOGY.

21. Mr. D. N. Wadia acted as Palæontologist throughout the year. N. K. N. Aiyengar, Field Collector, assisted the Palæontologist in routine Museum work and in the determination of specimens. When he was on leave these duties were attended to by M. S. Venkatram, Museum Assistant, in addition to other routine work. A. B. Dutt, Field Collector, completed the cleaning, relabelling and rearranging of the Klipstein collection in the Invertebrate Fossil Gallery.

22. During 1933 the following memoirs have been published in the *Palaeontologia Indica* :—

(1) L. F. Spath : 'Revision of the Jurassic Cephalopod Fauna of Kacch', Part VI of Memoir No. 2, Vol. IX of the New Series.

(2) F. Baron Von Huene and C. A. Matley : 'The Cretaceous Saurischia and Ornithschia of the Central Provinces of India', Memoir No. 1, Vol. XXI of the New Series.

(3) E. L. G. Clegg : 'Echinoidea of the Persian Gulf'. Memoir No. 1, Vol. XXII of the New Series.

The following papers of palæontological interest have appeared in the *Records* :

(1) 'Stratigraphic Significance of the Fusulinids of the Lower Productus Limestone of the Salt Range', by Carl O. Dunbar (Vol. LXVI, Pt. 4).

(2) '*Dadoxylon zalesskyi*, a new species of Cordaitean Trees from the Lower Gondwanas of India', by B. Sahni (Vol. LXVI, Pt. 4).

(3) 'A Fossil Pentalocular Fruit from Pondicherry, South India', by B. Sahni (Vol. LXVI, Pt. 4).

(4) 'Anthracolithic Faunas of the Southern Shan States', by F. R. Cowper Reed (Vol. LXVII, Pt. 1).

The following papers of palæontological interest are in the Press and are expected to be published in 1934.

Palaeontologia Indica.

(1) L. F. Spath : 'The Jurassic and Cretaceous Ammonites and Belemnites of the Attock District', Memoir No. 4, Vol. XX of the New Series.

(2) F. R. Cowper Reed : 'Cambrian and Ordovician Fossils from Kashmir', Memoir No. 2, Vol. XXI of the New Series.

Vertebrates.

23. Some mammalian bones, collected from a coal seam in the Kathmandu valley, Nepal, were sent to this Department by the British Envoy at the Court of Nepal, for examination. The collection, though fragmentary, included one bovid horn-core and a large limb-bone. The horn-core was despatched for examination to Dr. G. E. Pilgrim, who is now engaged in the revision of the Indian Cavicornia fauna. The large limb-bone, which was suspected to be a humerus of

Baluchitherium, a giant rhinoceros of Oligocene-Miocene age, was too imperfectly preserved for definite identification. However, on comparison it was found to resemble closely the left humerus of *Elephas* or an allied extinct genus belonging to the family Elephantidæ.

In the course of his field work, Mr. H. M. Lahiri made a collection of vertebrate fossils from Hari Talayangar (31° 32′ : 76° 37′ 30″), the famous fossil locality in the Bilaspur State, Punjab. The collection includes a few specimens that were purchased from the local people. The specimens, which were all obtained from the Middle Siwalik beds, have been provisionally identified by Messrs. Lahiri and Aiyengar as *Dryopithecus punjabicus*, Pilg., *Mastodon* sp., *Sivaonyx bathygnathus* (Lyd.), *Potamotherium* (?) *hasnoti*, Pilg., *Hipparion punjabiense*, Lyd., *Anthracotherium* (*Microbunodon*) *silistrense*, Pent., *Dorcatherium* sp., *Hydaspitherium megacephalum*, Lyd., *Tragoceras* sp., *Viverra* sp. and a few antelopine premolars.

At Malgin (33° 19′ 30″ : 71° 31′ 30″) in the Kohat district, North-West Frontier Province, a further collection of fossil fish was obtained from the thin shaly bands that are intercalated in the gypsum at the top of the Salt Marl. These have been sent to Dr. E. I. White of the Natural History Museum, South Kensington, London, for examination and description.

Dr. C. A. Matley, who conducted the Percy Sladen Trust expedition for the search of reptilian fossils in the Central Provinces, and was assisted in this work by Mr. A. M. N. Ghosh, reports that he obtained from the Lameta deposits of Jubbulpore on the slopes of Chhota Simla Hill, about a hundred and forty fossil bones, consisting of teeth, skull, limb-bones, vertebræ, etc., belonging to the sauropod and theropod dinosaurians. He is of the opinion that in this collection are included hitherto unknown parts of the anatomy of dinosaurs. He also believes that it is probable that all of the sauropod bones belong to a single individual, a circumstance which may help us to obtain a fuller knowledge of the size and shape of individuals belonging to the species. Dr. Matley mentions four new localities for fossil reptiles in South Rewah, namely west of Munda, south of Maliagura, near Ghunghuti on the Kachodar road, and south-east of Lakhanpura, from all of which dinosaurian remains were collected. In addition, he collected fragmentary limb-bones at Amakhoh.

A visit was also paid to Pisdura in the Chanda district, where besides dinosaurian remains, a fish vertebra and a large number of

fragments of a chelonian carapace were obtained from the surface of ploughed fields. Associated with these were abundant freshwater gastropods--*Paludina*, *Limnaea*, *Bullinus*, etc., characteristic of Intertrappean beds elsewhere.

21. The re-arrangement of the whole collection in the Invertebrate gallery has been completed; all the field collections as well as the duplicate collections are now arranged in stratigraphic order.

Invertebrates.

A collection of prepared specimens of Upper Cretaceous and Eocene limestones and marls from North-West India, containing the smaller foraminifera, has been sent on loan to Mr. Dale Condit of California University for study and comparison with micro-protozoa obtained from drill-cores of borings for petroleum in the Bahrein Island, Persian Gulf, by the Standard Oil Company. The results of this examination are likely to be of considerable value for stratigraphic purposes.

Dr. Matley and Mr. A. M. N. Ghosh found an abundance of fresh water Unionidæ in the Lameta scarp north of Amakhoh, Jubbulpore district. According to Dr. Matley this is the first find of molluscs in the Lametas of Jubbulpore district. Freshwater Intertrappean molluscs such as *Paludina*, *Limnaea*, *Bullinus*, etc., were also discovered by them at a number of hitherto unrecorded localities, especially east of Pinaora, Rewah State.

Dr. M. R. Sahni reports the discovery of several new Middle Jurassic (Bathonian) fossil localities in the Northern Shan States. The most important one is situated about half a mile east of Kongnim (23° 45′ : 97° 55′ 30″) and another about a mile south-east of Kawnghka (23° 50′ 30″ : 97° 59′). The chief interest lies in the presence of prolific lamellibranch faunas at both these localities. So far, practically no Bathonian lamellibranchs have been described from the Northern Shan States, the faunas consisting mainly of the Brachiopods *Burmirhynchia* and *Holcothyris*. Both these genera have been found at Kongnim associated with lamellibranchs, but they are absent from Kawnghka. Among the species identified are *Burmirhynchia namtuensis*, Buckman, *B. irregularis*, *B. senelis*, *B. shanensis* *B. hpalaiensis*, *B. namyuensis*, *B. depressa* and *Holcothyris pinguis*, *H. expansa*, *H. angulata*, as well as new species of *Holcothyris* and *Burmirhynchia*. The lamellibranchs belong to the genera ***Leda***, ***Nucula***, ***Mytilus***, ***Crassatellites***, ***Astarte***, ***Thracia***, ***Pecten***, ***Ostrea*** and ***Lima***.

Another interesting find is a *Fusulinid*, probably allied to *Schwagerina*, from the Plateau Limestone.

Reference was made in last year's report to the collections of fossils obtained by Mr. V. P. Sondhi from the Southern Shan States and sent to Dr. F. R. Cowper Reed of Sedgewick Museum, Cambridge, for examination, Dr. Cowper Reed has since reported that there is sufficient material for a memoir in the *Palaeontologia Indica*. He has, however, been requested to defer the preparation of such a memoir until he has examined further fossil collections obtained by Mr. Sondhi during the past field season from an area adjoining the one from which the previous collections were obtained. These collections, which come from 12 localities, have been registered in the Rangoon Office and have been forwarded to Dr. Cowper Reed.

The collections made by Mr. P. N. Mukerjee from the Bagh beds of Jhabua and Ali Rajpur States in Central India are noticed on page 71.

Plants.

25. The interesting collection of plant fossils collected by Mr. N. K. N. Ayengar of this Department in the Parsora area, South Rewah, has been sent to Prof. B. Sahni of the Lucknow University for examination.

Prof. Sahni has continued his researches on the post-Gondwana flora of India both on material supplied from this Department and that collected by himself, the results of which are to be incorporated in his forthcoming monograph on the fossil monocotyledons of India. Interesting results have been obtained from a detailed study of the silicified flora of the Deccan Intertrappean beds of the Nagpur-Chhindwara area, which, according to Professor Sahni, lend support to the view that the beds may be of Eocene and not of Upper Cretaceous age, the affinities of the flora as a whole being decidedly Tertiary rather than Cretaceous. Such a view, is, of course, opposed to the general view that the main portion of the Deccan trap is Maestrichian and Danian in age, as judged from the marine and fresh water mollusca which abound in some of the intercalated sediments both in the Peninsular and extra-Peninsular area. The main features of the Intertrappean flora are: a very marked preponderance of palms, a group of which appeared first in the Cretaceous, but gained enormously in importance during the Tertiary; the occurrence of *Nipadites*, a genus more typical of the Eocene than the older system; and the occurrence of an undoubted species of *Azolla* in some chert

blocks collected by Mr. H. Crookshank from the Sausar tahsil of Chhindwara district. The only previous fossil record of this genus is from the Tertiary of the Isle of Wight.

The Department's collection of the Indian fossil monocotyledonous flora, consisting of some 53 species of petrified stems, fruits and leaves, is being investigated by Dr. Sahni and he finds it possible to make some general observations thereon. The great majority of these fossils consist of petrified stems and thus our knowledge of the fossil monocotyledons is chiefly based upon the anatomy; this is satisfactory from the point of view of specific determinations; but, on the other hand, owing to the scarcity of leaf-impressions our knowledge of the habit of these plants remains meagre. Perhaps the most striking feature of the Indian fossil monocotyledonous flora is the great preponderance of palms, the only other families yet definitely recognised being the Gramineae and the Zingiberaceae.

During a visit to Jatta (33° 18′ 30″ : 71° 17′ 30″), Kohat district, North-West Frontier Province, Mr. E. R. Gee found well-preserved fossil leaves, probably of dicotyledonous type, in certain thin bands of soft clay and sandstone that are interstratified with the grey rock-salt of the salt quarries of that area. From the red marl associated with the rocksalt and topmost gypsum, he obtained a number of foraminifera.

Donations.

26. During the year under review, presentation of fossils were made to the following institutions:—

Geological Survey of the Dutch East Indies, Bandoeng, Java. A collection of vertebrate and invertebrate fossils. (By exchange).

Geological Survey, New South Wales, Department of Mines, Australia.—Some Permo-Carboniferous fossils from the Salt Range, Punjab. (By exchange).

Palaeontological Museum, Munich University; Natural History, Geology and Palaeontological Department, Vienna University; American Museum of Natural History, New York: Peabody Museum of Natural History, Yale University, New Haven, Connecticut; National Geological Survey of China, Peking.—Small collections of fossil corals from the Jurassic beds of Kachh, Western India.

Osmania University College, Hyderabad, Deccan.—A representative collection of fossil vertebrates, invertebrates and plants.

University of Liverpool, Department of Geology.—A small collection of fossils consisting of vertebrates, invertebrates and plants. (By exchange).

Judson College, Rangoon University, Rangoon.—Some fossil plants from the Gondwana formations.

Geological Survey Department, Tanganyika, Dodoma, East Africa.—A representative collection of vertebrate, invertebrate and plant fossils of India.

Bengal Engineering College, Sibpur.—About eighty fossils consisting of vertebrates, invertebrates and plants for educational purposes.

During the year donations of fossils or casts of fossils were received either by exchange or by presentation from the following institutions or persons—

University of Liverpool, Department of Geology.—A collection of Ordovician and Silurian graptolites of England. (By exchange, through Prof. H. H. Reed).

Royal School of Mines, South Kensington, London.—Some Palæozoic and Mesozoic invertebrate fossils of Europe. (By exchange, through Prof. Morley Davies).

Geological Survey of the Dutch East Indies, Bandoeng, Java.—A collection of vertebrate and invertebrate fossils. (By exchange).

Geological Survey, New South Wales, Department of Mines, Australia.—A small collection of Permian fossils. (By exchange, through Mr. W. S. Dunn).

Mr. E. Goodwin, Superintendent, Northern India Salt Revenue Department.—A number of Lower Siwalik fossils from Malgin, Kohat district, North-West Frontier Province, including a portion of the jaw of a rhinoceros

STRATIGRAPHY.

Blanford's Champaner beds.

27. In the Panch Mahals district and Rewa Kantha States, W. T. Blanford[1] has described the metamorphosed sedimentaries east of Pavagad Hill under the local name of the *Champaner* beds, leaving the question of their geological horizon open. Dr. A. M. Heron[2] in 1917 suggested that the nearest analogue of the Delhi system

[1] *Mem. Geol. Surv. Ind.*, VI, pp. 189, 202 (1869).
[2] *Op., cit.*, XLV. Pt. 1, p. 110, (1917).

is the Champaner series. Dr. Heron's examination of the Champaner rocks this year has shown that this suggestion is untenable, as they have no particular resemblance to the rocks of the Delhi system, but are lithologically identical with the Aravallis of Rajputana, with which they have in fact been proved by Dr. Heron and his party to be continuous.

I have myself in the past given some attention to the nomenclature of these ancient rock series, and in the course of my study of the manganese-ore deposits of India was led to conclude in 1909 that[1] 'the series that have received the following names, arranged in order of priority, are roughly contemporaneous:—Champaner (1869), Aravalli (1877), Chilpi Ghat (1885), Dharwar (1886), and portions of the metamorphic and crystalline complex[2] of the Nagpur and Balaghat area, Central Provinces'.

Concerning the use of these terms I wrote as follows (*loc. cit.*) :—

'With regard to the question as to which term is to be adopted in preference to the others, it is obvious that according to the rules of priority the term *Champaner* should be used. This, however, is the name that has been the least used of all, whilst that which has been extended to the largest number of areas, has passed into most general use, and is known best to geologists and miners, is the term *Dharwar*, the familiarity of the name being largely due to the fact that the auriferous veins of Mysore are situated in the rocks to which this name was originally given. Since, however, the strict contemporaneity of these in various parts of India has not and never can be proved, partly because they are situated in isolated areas and partly because it does not seem probable that the sedimentation in the different areas can have started and finished at exactly the same points of geological time, it will probably always be considered preferable to employ the local names with a general understanding as to their rough equivalence. When, however, it is desirable to treat the rocks of the different areas as a whole, it will be better to use the most familiar of the local names, namely *Dharwar*, in preference to that which has priority on its side, but happens to be the least generally known of all namely *Champaner*.'

It is very satisfactory that Dr. Heron has now been able to prove definitely by continuous mapping the equivalence of two of these series, namely the Aravallis and the Champaners, and in accordance with the reasoning of the paragraph quoted above, I agree with him that the term *Champaner* can now be discarded as a local term in favour of *Aravalli* throughout Rajputana and North Bombay.

The definite proof of this equivalence is particularly important as enabling us to effect a measure of correlation between the old

[1] *Mem. Geol. Surv., Ind.*, Vol. XXXVII, p. 283, (1909).
[2] Now known as the *Sausar series*. See *Rec. Geol. Surv. Ind.*, LIX, p. 78, (1926).

rocks of Rajputana and ancient schistose formations elsewhere in India from which Rajputana and North Bombay are separated by the main tract of the Deccan trap formation. The Champaner rocks of Gujarat and the Aravallis of Jhabua both contain manganiferous rocks, which I have long regarded as probably contemporaneous with the gonditic rocks of the Central Provinces and Gangpur, forming a part of what we now term the Sausar series; and as the mapping of Dr. Krishnan in Gangpur State has shown the position of the Sausar series with respect to the Iron-ore series of Singhbhum, we are now well on the way to being able to effect a satisfactory correlation of the Aravalli rocks of Rajputana and North Bombay with the rocks of Dharwarian type in the Central Provinces and Chota Nagpur, assuming that it is safe to utilise the manganiferous rocks as a stratigraphical datum line in the Archaeans having the same importance as characteristic fossils higher in the stratigraphical sequence.

Cambrian beds in Kashmir.

28. In the Annual Report for the year 1931[1], it was stated that Mr. D. N. Wadia was able to prove on the evidence of fossil trilobites that the thick series of slates occupying the wide belt of mountains between the Kishenganga and Middlemiss and Bion's area in the Sind valley of North-West Kashmir is of Cambrian or Cambro-Silurian age. The whole of Mr. Wadia's collections from this slate zone were sent to Dr. Cowper Reed for his examination and description. The results of Dr. Reed's study have been received and they point unmistakably to a Middle and Upper Cambrian age for the fossils from the slate belt. Dr. Reed has identified 16 genera of trilobites and seven of brachiopods, the majority of the genera and almost all the species being new to India. The most interesting result of Dr. Reed's identification is that there is little resemblance to the faunas of corresponding age in the Spiti region of the Central Himalaya, in the Salt Range, or with the little known Cambrian faunas of Persia and the Dead Sea, but there are several noticeable links with the Cambrian of French Indo-China. One of the most remarkable occurrences is that of the genus *Tonkinella* found previously only in Tonkin.

The Cambrian system as developed in North-West Kashmir shows a very full development, aggregating 7,000 feet in total thickness of deposits. This is the first recorded occurrence of marine Cambrian

[1] *Rec. Geol. Surv. Ind.*, LXVI, p. 122, (1932).

deposits on the south of the main crystalline axis of the Himalaya. From the point of view of Himalayan stratigraphy, however, the chief interest of the present area lies in the relation of the Purana slate zone of the middle Himalayan ranges with the fossiliferous Cambrian. Clear evidence of a conformable, if not a gradual or transitional, passage of the unfossiliferous slates into beds bearing annelids and other indubitable organic remains, and of these again into strata containing trilobites and brachiopods of Middle Cambrian affinities, has been obtained by Mr. Wadia in a number of sections along the outer margin of the marine Palaeozoic basin of Hundwara.[1]

ECONOMIC ENQUIRIES.

Antimony-ore.

Southern Shan States, Burma.

29. In a traverse across the Pindya range, Mr. Sondhi saw some old workings for stibnite just to the south of Mene-taung village (20° 59′ : 96° 37′). The mineral occurs close to the surface, apparently in a north-south vein in a highly argillaceous limestone which weathers into soft yellow clay in clusters of acicular, radiating crystals. It was worked in a small way many years ago.[2]

Apatite.

Singhbhum, Bihar and Orissa.

30. Continuing the survey of the copper belt south from Mushabani mine, Dr. Dunn visited the magnetite-apatite deposits at Badia, Bhadua, Kanyaluka, Sungri, and Khejurdari in Dhalbhum, examined by me some years ago when they were being worked by the Great Indian Phosphate Company.[3] The mining of these deposits has since completely ceased.

Dr. Dunn's systematic survey has demonstrated the close relation of these deposits to outcrops of tongues of soda-granite which ascended along the thrust zone in Singhbhum. With the sulphides these apatite lenses show a zonal deposition: along the strike of the thrust zone apatite deposits are found close to or within granite,

[1] *Op. cit.*, pp. 122-123.
[2] *Rec. Geol. Surv. Ind.*, LXVII, p. 242, (1933).
[3] *Op. cit.*, L, p. 14, (1919).

whilst sulphide deposits may be several miles from any known granite outcrops.[1]

The apatite and magnetite are now regarded by Dr. Dunn as having crystallised from definite melts and not, as previously thought by him, by reaction of solutions with the 'country' rock.[2] The view adopted by me some years ago was that the magnetite-apatite-rocks might have been expected to be igneous introductions analogous to the apatitic magnetite ore-bodies of Lapland, but that the facts would be better explained by regarding these rocks as due to pneumatolytic introductions from the Singhbhum granite.[3]

Asbestos.

Singhbhum, Bihar and Orissa.

31. Dr. A. K. Dey reports the occurrence of asbestos apparently resulting from the alteration of basic and ultra-basic rocks of the Dalma suite at localities about half a mile S.S.E. of Lipkocha (22° 25′ : 86° 30′), north-east and 1¼ miles east of Mahespur (22° 23′ : 86° 30′), and 1½ miles west of Chirutanri (22° 24′ : 86° 34′), in Dhalbhum.

Barytes.

Southern Shan States, Burma.

32. Mr. Sondhi reports the occurrence of barytes in the south-eastern ridges of sheet 93 C/16 at two places in the Thitteikyan beds, one about 1½ miles E. S. E. of hill 5,098 feet and another half a mile south west of hill 5,028 feet. At each place the outcrop is from 12 to 15 feet long and from three to five feet wide.

Bauxite.

Northern Shan States, Burma.

33. Dr. Sahni reports the occurrence of a small outcrop of a pisolitic residual rock on dolomites of the Plateau Limestone near the Palaung village of Pangnim (23° 33′ : 97° 50′) in the Northern Shan States. The following is the average analysis of several specimens :—

	Per cent.
SiO_2	33·19
Al_2O_3	32·67
Fe_2O_3	15·81

[1] The rough zonal distribution of these and some other ore-deposits in Singhbhum was discussed by me in 'Some Problems of Ore Genesis in the Archaean of India', *Proc. As. Soc. Beng.*, (New Series), XV, pp. clxxxviii-cxci, (1919).

[2] *Rec. Geol. Surv. Ind.*, LXIII, p. 28, (1930).

[3] *Op. cit.*, L, p. 15, (1919).

Whether this is to be regarded as a very siliceous bauxite or a pisolitic aluminous clay depends on whether the silica is in the free or combined condition.

Beryl.

Nellore district, Madras Presidency.

34. Beryl is a mineral occurrences of which are always worth recording either from the economic or the scientific point of view. Economically the mineral may be of use either as a gemstone or as a source of beryllium for beryllium alloys. Scientifically beryl may be of use as an indicator of the minimum age of the containing rock. [1]

It is for the last reason that one may mention the occurrence, noticed by Dr. P. K. Ghosh, of small quantities of beryl, too greatly cleaved and fractured to be used as a gemstone, from some new localities in the mica belt of Nellore, *viz.*, from the Pallimita, and the Virabhoga and Rustum mica mines.

Building Materials.

Singhbhum, Bihar and Orissa.

35. In the neighbourhood of Dhalbhumgarh station, Dhalbhum, a pebble bed, which forms the base of a group of sediments regarded by Dr. Dunn as of late Tertiary age (see page 83), has been extensively quarried for many years and used as railway ballast. South of the same station massive white quartz veins in a belt of mica-schists are being quarried for road metal.

36. Dr. A. K. Dey reports that the principal source of lime in Dhalbhum is *kankar* which occurs on the surface of the Iron-ore series. Occasionally, however, a kind of calcareous tufa, usually containing a net-work of tubes, is found in the crevices of quartzite or as an incrustation on it. The supply is limited.

The deposits are locally known as *ashurhar*[2], meaning demons' bone. The deposit near Basadera (22° 40′ : 86° 30′), recorded by Ball[3], has been nearly worked out. In course of his work in Dhalbhum Dr. A. K. Dey found two other deposits of such tufa in the quartzite cropping out in the *nalas* to the north-west of Bakrakocha

[1] Lord Rayleigh.
[2] Ball, *Mem. Geol. Surv. Ind.*, XVIII, p. 49, (1881).
[3] *Loc. cit.*, p. 88.

(22° 24′ : 86° 30′) and 1¾ miles north-west of Khejurdari (22° 24′: 86° 33). The supply is very limited.

37. Mr. P. N. Mukerjee reports the occurrence of well-cleaved and fine-grained phyllites and slates, in abundance, in Jambughoda State, Panch Mahals district. These rocks, which belong to the Aravalli (Champaner) series, are very well developed between the old fort of Narukot and the village of Jaban (22° 24′ : 73° 11′ 30″), on the Shivrajpur-Jambughoda road, and might afford good roofing slates.

Jambughoda State, Bombay Presidency.

38. Mr. P. N. Mukerjee also reports that the Infratrappean gritty sandstone, near Nathkua village (22° 26′ : 73° 35′ 15″), south-east of Pavagad Hill, contains innumerable quarries from which came building stone used in the old city of Champaner and the extensive fortifications of Pavagad Hill.

Halol taluka, Panch Mahals, Bombay.

39. The Tawng Peng granite is, so Dr. Sahni reports, locally used as a building stone for bridges and wells. Nearly all the bridges in the granite area are constructed of granite blocks; but no big quarries exist and the material used is, therefore, weathered and not very suitable for the purpose. However, when suitably quarried the granite should make a good building stone.

Northern Shan States, Burma.

Chromite.

40. Dr. P. K. Ghosh was deputed to report during the season on the occurrence of chromite in the Ratnagiri district. According to him, the deposit occurs in the valley of the Gad river, one mile to the N. N. E. of Kanakauli village (16° 16′ : 73° 45′), in the Devgadh *taluka* of the Ratnagiri district.

Ratnagiri district, Bombay Presidency.

The deposit occurs as a roughly E.-W. dyke or vein, about half a mile in length, with a width varying from 30 to six feet, and intersecting the foliation of the older, pre-Cambrian, gneisses and schists. It is probably also of pre-Cambrian age.

The ore-body is associated with serpentine which appears now and then at the centre of the mass. There has been no separation of clean ore; instead the chromite occurs mostly as disseminated grains in serpentine and chlorite. Assays yield 34 to 41·58 per cent. $Cr_2 O_3$, so that unless the quality improves with depth the ore will not, without concentration, be of much value in normal times.

Clays.

Kathiawar, Bombay Presidency.

41. According to Dr. P. K. Ghosh, a bluish plastic clay, found one mile S. S. W. of Gogha (21° 41′ : 72° 19′) in Kathiawar, is used for making casts and moulds. It is exported in large quantities to Bombay, but no returns of its production are available. The clay formation is a member of the Tertiaries exposed in the neighbourhood of Gogha.

Nellore district, Madras Presidency.

42. According to Dr. P. K. Ghosh also, there is a China clay deposit in the now extinct Malatippa mica mine, half a mile north of Kistama mica mine (14° 27′ : 79° 46′), Nellore district, Madras Presidency. It represents a highly kaolinised pegmatite intruded into quartzite, and the surface-exposure measures about 20 feet by three feet. The deposit may be of local importance, but its narrow width, combined with the highly inclined nature of the original pegmatite, would make its working rather difficult.

Copper-ore.

Southern Shan States, Burma.

43. On the eastern scarp of the Pindaya range west of Zawgyi village (20° 50′ : 96° 40′), Mr. Sondhi discovered a vein about three feet thick, consisting mainly of barytes and calcite, but also containing small amounts of malachite.

Singbhum, Bihar and Orissa.

44. During the season 1932-33, Dr. J. A. Dunn completed the survey of the copper belt, Singhbhum. Continuing south from Mushabani (Mosaboni) the old workings one mile to the south, at Badia, were examined. It is obvious that the Badia and Mushabani deposits are associated with the same zone of mineralisation. The evidence of veins north of Mushabani, that is, west of Laukesra, and those at Badia, suggest that west of the present Mushabani mine lodes there is the possibility of a continuous mineralised zone adjacent to the western edge of the soda-granite which forms the 'country' of the Mushabani lodes. This line well deserves prospecting, even if only because it would be so easily and cheaply investigated.

With commencement of development of the Dhobani lodes and the favourable nature of these other adjacent lodes, the prospects of a successful future for this mine are, according to Dr. Dunn,

bright—providing of course that capital and plant capacity are kept well within the known ore reserves.

South from Badia the thrust zone, which has in the section to the north been the determining factor in the localisation of payable lodes, gradually dies out and no copper lodes of any importance are found. In the granite to the north-west of Baharagora (Bhairagora) however, several lines of ancient copper workings show features sufficiently attractive to warrant future prospecting.

Dr. Dunn has studied both the Rakha and Mushabani ores by reflected light. He has detected the presence of a nickel sulphide whose properties identify it with the recently found rare mineral violarite. The colour is, however, galena-white instead of the typical violet of normal violarite; but similar galena white specimens have been described in America. In the Singhbhum ores violarite replaces pentlandite to a variable extent, and is the most abundant nickel sulphide. Another nickel-bearing sulphide, identified as millerite, replaces and is intergrown with pyrrhotite.

The sequence of the sulphides in these ores is apparently pyrite, pyrrhotite and pentlandite, violarite and millerite, chalcopyrite. Minute amounts of other minerals not yet determined are also present.

Dr. Dunn now concludes that although the apatite-magnetite-rocks and sulphides belong to a late phase of mineralisation by the granite tongues intruded along the thrust zone, they were deposited from separate solutions. The earliest was a simple apatite magnetite melt which crystallised out at high temperatures; the latest sulphides were deposited at much lower temperatures.

Bastar State, Central Provinces.

45. Mr. Crookshank reports green malachite stains on the surface of a brecciated quartzite cliff north of Mundanar (18° 49′ : 81° 46′). A little copper-bearing pyrites is disseminated through this quartzite for a distance of about one mile. The occurrence is of no economic importance as the amount of pyrites present is very small.

A small boulder, richly impregnated with sulphides and malachite, was also picked up on a jungle path $1\frac{1}{2}$ miles south of Pakanar (18° 53′ : 81° 44′), but the source from which it came could not be traced.

Engineering and Allied Questions.

46. At the instance of the Corporation of Rangoon, Messrs. E. L. G. Clegg and V. P. Sondhi reported on the geological aspects of the

Gyobyu and Nyaunglebin Lakes scheme, which is one of the few that aim at supplying Rangoon with water by gravity from the western slopes of the Pegu Yomas. The two catchment areas lie within the Hlaing Yoma reserve forests on sheet 94 C/3, six to eight miles from Taikkyi, a town about 42 miles from Rangoon on the Prome railway line.

The Gyobyu and Nyaunglebin Lakes scheme, Rangoon, Burma.

Both the catchment areas lie completely enclosed within rocks of the Pegu series, but their geological structures differ. The Gyobyu catchment area of 13·1 square miles comprises the Gyobyu *chaung* and its tributaries of which the most important is the Mezali; and with a dam of about 121 feet in height at the site selected, a yield of 18 million gallons per day is estimated.

The rocks of the Pegu series in this area consist predominantly of shales intercalated with sandstones. In general the shales are well-bedded, micaceous and sandy and are interlaminated with thin layers of fine sand, but pure blue shales are not unknown. The sandstones are mostly very fine-grained with very little cementing material, and most of the beds seem to be consolidated by pressure alone. From a fossil bed in the Ngakyi (Nagyi) *chaung*, about a furlong and a half upstream from its confluence with the Mezali *chaung*, which consisted of many broken lamellibranchs, a *Cardium*, together with a number of fish teeth allied to *Carcharodon megalodon*, Agassiz, and *Carcharia* (*Prionodon*) *egertoni*, Agassiz, were obtained. A partly rolled piece of fossil wood, about six inches long and three inches broad, was also collected.

In the main Gyobyu valley and the larger of its tributaries, a highly ferruginous deposit of rolled pebbles and grains of soft shale and sandstone overlies the upturned edges of the Pegu rocks. The bed has an average thickness of about ten feet and is strongly cross-laminated. It is in turn overlain by silt terraces, the remains of three of which exist in the Gyobyu valley. The ferruginous bed as well as the terraces will be totally submerged when the dam is built and the water rises to the intended height.

The Gyobyu catchment area is synclinal in structure, the ideal structure from a water-holding standpoint when composed of an alternating series of permeable and impermeable rocks, such as the shales and sandstones of this area.

Rocks exposed at the dam site range from fine-grained sandstones to shaly sandstones, depending on the proportion of their sand content.

They are consolidated by pressure and contain only clay as a cementing material. Elutriation tests on samples from them point to their permeability being negligible and as they have a resolved dip up-stream into the catchment area the site was considered satisfactory.

47. The Nyaunglebin catchment with its area of only 2·1 square miles and estimated yield of about 5 million gallons per day, lies immediately south of the Gyobyu area, a narrow ridge separating the two. It is intended to supplement the yield of the Gyobyu lake at some future date when the necessity arises.

The physical conditions obtaining in this area and the character of the rocks exposed in the stream beds are essentially the same as those found in the Gyobyu area, but the geological structure of the beds differs. The sandy shale and fine-grained sandstones of the Pegu series in this area dip persistently to the west at from 10° to 15°, but further west outside the catchment area and near the boundary with the Irrawaddian series, the dips become very marked, although no change in direction takes place. Faulting is perhaps indicated.

The proposed dam line of this area runs approximately W. S. W. - E. N. E. across a gorge whose sides are decomposed into fine sandy soil on the highest elevations with fine-grained sandstones containing partings of shaly material below. In the stream-bed itself fresh sandy shales with thin sand layers are seen interbedded with thick beds of fine-grained false bedded sandstone dipping slightly south of west at from 15° to 20°. The rocks thus have a small resolved dip down stream, but as their permeability is very low, Messrs. Clegg and Sondhi anticipate no danger, providing the foundation is anchored in fresh rock. The catchment area is also considered satisfactory owing to this same impermeability, although it possesses none of the structural advantages of the Gyobyu area.

Messrs. Clegg and Sondhi draw attention to the following points bearing on the type of dam for the proposed reservoirs :—

(1) The low crushing strength of the rock at the dam sites.
(2) The fact that the foundations cannot be located on one homogenous band of strata of a uniform crushing strength.
(3) The area is situated in an active earthquake zone.

48. At the request of the Government of India, Dr. C. S. Fox was deputed to examine the site for a proposed storage dam for an

irrigation reservoir in the Bhavani valley, near the confluence of the Moyar and Bhavani rivers (11° 28′ : 77° 6′) in the Coimbatore district. Two possible sites for this dam were examined by Sir Thomas Holland (then Mr. Holland) as long ago as 1898, but no action was taken on his report. The project has now, however, been revived and pits and trenches have been made to record the nature of the rock junctions between the amphibolite and the gneiss at one of these sites. Dr. Fox is of the opinion that the site is geologically satisfactory. He recommends, however, that systematic core drilling should be undertaken on the river and alluvial section of the dam site to ascertain the nature and depth of the solid rock. He also advises a masonry dam instead of an embankment of earth-work.

Bhavani dam-site, Coimbatore district, Madras Presidency.

49. During the month of March, Mr. E. R. Gee visited the military encampment at Mir Ali (32° 59′ : 70° 16′ 45″), Waziristan, in order to investigate the cause of the damages incurred by the brick buildings since their construction during the past two to three years.

Military encampment, Mir Ali, Waziristan, North-West Frontier Province.

Mr. Gee observes that the camp is located on a low ridge just north of the Miran Shah road, 24 miles west of Bannu. The strata include steeply dipping green clays capped by a loose, high-level pebble bed (Older Alluvium). Cracks have occurred in the ground and in a number of the buildings. He suggests that these are due to:

(*a*) Relative weakness of structures—small foundations with brick and mud-mortar superstructures.

(*b*) Looseness of underlying pebble beds, which are quite unconsolidated.

(*c*) Percolating water, draining over the surface of the underlying clays.

(*d*) Earthquake shocks.

He is of the opinion that the buildings are liable to be severely damaged should a serious earthquake occur. He suggests that all heavy mud roofs and chimneys should be removed and the various parts of the buildings braced together as much as possible.

Garnet.

50. Dr. P. K. Ghosh notes that workable quantities of garnet in crystals measuring up to 1½ inches in diameter are obtainable over

an area of half a square mile in the hill half a mile west of Korissa Kunda (14° 11′ : 79° 43′), Nellore district, Madras. Besides being a constituent of the country-rock, garnet is found in a fairly concentrated state in the surface detritus of the hill, so that the working of the deposit should be very simple.

Nellore district, Madras Presidency.

Gem Mining.

Mogok Stone Tract, Katha district, Burma.

51. In the General Report for 1927 [1], an account is given of Dr. Coggin Brown's report on the history of the ruby mining industry in the Mogok Stone Tract, Upper Burma. This investigation revealed the necessity of a detailed geological survey of the gem-bearing tract before a satisfactory decision could be taken on the policy to be followed in the regulation of this industry for the future.

On the completion of new topographical maps on the scale of four inches to the mile prepared specially for the purpose, the detailed geological survey was commenced [2] in 1932-33 by Mr. E. L. G. Clegg and Dr. Narayana Iyer and the results of their geological work is given under 'Geological Surveys' (see page 50).

It is desirable, however, to publish here the present position regarding the grant of gem licenses in the Mogok Stone Tract as summarised by Mr. Clegg.

Licenses to mine for stones in the Mogok Stone Tract are of two kinds :-

(1) Extraordinary licenses, which are licenses to dig for and raise stones by any method.

(2) Ordinary licenses, which are licenses to dig for and raise stones by native methods and do not authorise the use of any explosive substance or machinery except as provided by the rules. Under the rules special licenses to use mechanical pumps (gravel pumps prohibited) and explosives may be issued to the holders of ordinary licenses.

Originally the sole right to an extraordinary license was held by the Burma Ruby Mines Company, whilst hereditary miners work-

[1] *Rec. Geol. Surv. India.*, LXI, pp. 53-56, (1928).

[2] Mr. A. K. Banerji had actually commenced detailed work in 1931 on the existing Forest Survey sheets pending the completion of the new survey.

ing under ordinary licenses were restricted to such methods of working as they had used in the past, that is, to the ordinary handworked bamboo pump for the pumping of, and the balanced bamboo lever, such as is used in wells all over the east, for the bailing of, water, or for the raising of the ruby-bearing earth or *byon* to the surface.

Since the termination of the lease of the Burma Ruby Mines Company in 1931, the Government of Burma have removed all restrictions with respect to applications for extraordinary licenses. The sanction of the Governor-in-Council is, however, required before such a license can be granted.

In the past, large-scale mining by the Burma Ruby Mines Company has proved a failure, whilst mining under ordinary methods by native miners is known to have been a success. Many areas in the stone tract are unsuitable for work by native methods owing to the inability of the miners to cope with water seepage. These areas can however be dealt with by the small capitalist by the use of mechanical means, and the first extraordinary license under the new rules was issued in 1933 over an area of 10½ acres in the Engyauk gorge immediately north-east of Mogok. The terms on which the license was issued are roughly as follows :- Rs. 20 per month per miner employed (as against Rs. 10 per month paid by the ordinary miner) with a minimum miners' fee of Rs. 400 per month, plus an acreage fee of Rs. 5 per acre, or 10 per cent. of the sale receipts of the stones mined whichever is greater. Certain conditions are also included in the lease regarding returns and the payment of royalty on unsold stones on the termination of the lease. The license is issued for twelve months only in the first instance with the option of renewal for further periods on such rates and conditions as may be prescribed by the Local Government.

It will be interesting to see how the terms work out in actual practice and how far fairly small-scale mining by modern methods combined with personal and self-interested supervision can be made a paying proposition.

Gold.

52. Gold in Dhalbhum is found both in river alluvium and in certain quartz veins. Quartz veins in Singhbhum are of two varieties, a barren white massive quartz, and a smoky grey or 'blue' quartz, often sheared. The latter type is occasionally auriferous. Such gold-bearing quartz veins are found in the Iron-ore series only

Singhbhum, Bihar and Orissa.

in the upper zone of tuffs. Their distribution suggests to Dr. Dunn a relation with the late basic intrusive phase of the Dalma volcanic suite and not with the granitic rocks of the area, as was suggested by myself some years ago. [1]

Northern Shan States, Burma.

53. Dr. Sahni reports the occurrence of alluvial gold in several streams draining the Chaung Magyi rocks, as, for example, in the bed of the Nam Lawng, south of Urapum (23° 41′ 30″ : 97° 55′ 30″) and S. S. W. of Hkamtaw (23° 41′ : 97° 53′). The main gold-bearing area lies to the east of sheet 93 E/13 and here the Burma Corporation and others have been carrying on intensive prospecting for some time. Fairly large-sized pellets of gold were brought to Dr. Sahni by the Shans for examination. It appears that the area was worked for gold in former times by the Chinese and traces of their workings still exist. Certain localities which the Chinese overlooked or could not reach are still reported to be richly gold-bearing.

Iron-ore.

Singhbhum, Bihar and Orissa.

54. Dr. A. K. Dey found pebbles of ilmenite associated with asbestos north-east of Mahespur (22° 23′ : 86° 30′) in Dhalbhum, the 'country' being altered epidiorite. Certain shales and quartzitic schists south of Shamadanga (22° 12′ : 86° 32′) are highly ferruginous and often grade to hematite-phyllites and hematite-quartz-schists; these in places form small deposits of hematite. Such deposits of iron-ore possess, however, no economic value in view of the vast quantities of iron-ores in the Kolhan.

Kathiwara State, Central India.

55. Mr. P. N. Mukerjee reports an occurrence of micaceous haematite in the Nimar sandstones, south of Ghunt village (22° 32′ : 74° 5′) in Kathiwara State, Central India. This deposit also is only of academic interest.

Bastar State, Central Provinces.

56. Mr. P. N. Bose's surveys in 1898-1900 showed that large deposits of hematitic iron-ore exist in Bastar State.[2] Mr. H. Crookshank now reports the existence of large quantities of low grade lateritic iron-ore on the ridge one mile south of Guinjenar (18° 47′ : 81° 35′), and on the south side of the Kaingar valley south-west of

[1] *Proc. As. Soc. Bengal,* N. S., XV, p. clxxxix, (1919)
[2] General Reports for 1898-99 and 1899-1900, pp. 38 and 41 respectively.

Kotomsor (18° 52′ : 81° 58′), and minor deposits in connection with most of the patches of hematite-quartzites. These ores are extracted on a small scale by the village iron-makers in many localities.

Kyanite.

57. Dr. A. K. Dey noticed kyanite debris strewn on the ground west of Singpura (22° 22′ : 86° 35′) in Dhalbhum. The mineral is bluish white in colour and occurs in large interlocking blades associated with muscovite and some talcose mica that may be damourite.

Singhbhum, Bihar and Orissa.

58. Dr. P. K. Ghosh records the occurrence of abundant kyanite in blades sometimes attaining a length of six inches, in garnet-staurolite-biotite schists injected by quartz veins, in the hill half a mile west of Korissa Kunda (14° 11′ : 79° 43′), Nellore district. It is found abundantly in the surface detritus.

Nellore district, Madras Presidency.

Lead-ore.

59. In the course of his survey of part of the Khasi and Jaintia Hills, Assam, Mr. Bradshaw noticed the occurrence of galena in boulders of pegmatitic granite close to the boundary between the granite and epidiorite south of Umwang (25° 41′ : 92° 12′). The boulders in which galena was noticed were not *in situ* and Mr. Bradshaw does not consider the occurrence to be of economic importance.

Khasi and Jaintia Hills, Assam.

60. About half a mile north-east of Khandia village (22° 19′ 30″ : 73° 35′ 30″) in the Bhamria State, Panch Mahals, there is, according to Mr. P. N. Mukherjee, a deposit of galena in irregular veins in mica-schists. The mineralised band extends for about a mile to the east, and is about five feet wide. The veins carrying the ore have a general E.–W. trend, approximately corresponding with the strike of the mica-schists. A sample of the galena assayed in the Geological Survey Laboratory gave 18·16 oz. of silver per long ton.

Bhamria State, Panch Mahals district, Bombay.

The deposit requires careful investigation and may turn out a very useful occurrence.

61. The belt of the lead-silver-ore of Mawson[1], sheet 93 D/13, was found by Mr. Sondhi to continue to the north into sheet 93 C/16,

[1] *Rec. Geol. Surv. Ind.*, LXV, p. 52, (1931).

Southern Shan States, Burma.

and ancient Shan pits and large quantities of slag were noticed at a number of places, especially about half a mile to the east of Thitteikkon (21° 1′ : 96° 48′) and on the top of the well-defined ridge about two miles E. S. E. of the same village. In the latter area Shan pits are concentrated along a fault line.

The area has been the scene of active prospecting in recent times, but is now deserted.

Mica.

Nellore district, Madras Presidency.

62. During the latter part of the field-season of 1932-33, Dr. P. K. Ghosh visited Nellore district at the request of the Government of Madras to investigate the 'behaviour of mica deposits of Nellore at great depths, and the relation of the presence of hornblende- and biotite-schists to the occurrence of mica'. He was accompained by Mr. C. Sriramulu, the Officiating Mica Inspector of Nellore, practically throughout the whole period of his tour in the district.

At the time of his visit, only eight mines, *viz.* Patheregunta, Shah, Nityakalyani, Radhakrishna, Inam, Newlands, Tellabody and the D. mines, were working. Besides the above-mentioned mica mines, practically all the other mica mines of Nellore were visited. But being under water, the unworked mines offered very little facility for observing the behaviour of mica in depth.

The geological formations met with in the mining area are as follows :—

Pegmatite (often carrying mica, and sometimes beryl and samarskite) and quartz veins.

Schistose quartzite (? original quartz veins).

Highly sheared granite-gneiss.

Amphibolite and hornblende-schists, sometimes passing into epidote-schists.

Biotite-schist (often carrying garnet, kyanite, staurolite) and talc- and chlorite-schists.

The main mica belt of Nellore is sickle-shaped, tapering to the south-east and to the N. N. E.; the southern point lies nine miles to the S. S. E. of Gudur (14° 9′ : 79° 52′), and the northern point about nine miles to the N. N. E. of Sangam (14° 35 : 79° 45′). The lens-shaped central portion, which runs roughly

north and south, and is widest in the southern and eastern portions of the Rapur *taluka*, carries most of the mica mines (including the most paying ones) of the district. The mica belt between latitute 14° 3′ and the Kandleru river, is marked by schistosity trending between N. W.-S. E., and N. N. W.-S. S. E., with high south-westerly or south-south-westerly dips. North of the Kandleru, schistosity tends to be more or less N.-S., or even N. E.-S. W., and high easterly dips are frequent. Although the above is generally the case, the direction of strike and dip of individual bands may vary from place to place.

The pegmatites, which are the latest intrusions, conform in strike and dip to the schistosity of the 'country', seldom show any signs of pressure metamorphism, and seem generally to have crystallised under quiescent conditions. The thickness of the pegmatites is variable, ranging from that of an insignificant vein to over 200 feet; but ten to 15 feet may be taken to be the average thickness of mica-yielding pegmatite. The length also is variable, from an average of 30 feet to over 1,200 feet. As Mr. G. H. Tipper recorded in his report on the mica mines in the Nellore district, 'the commonest form of these (pegmatites) is that of a lens, a series of connected lenses, lenses arranged *en echelon*, or long irregular masses'. They are often associated with a well-developed boss of quartz—a product of differentiation of the pegmatite magma.

The larger, workable pegmatites seem to have a distinct preference for the biotite-schist zones, into which the largest number of pegmatites are found intruded. It should be mentioned, however, that workable quantities of mica have also been found in pegmatites intruded along the junction of the biotite- and hornblende-schists (Patheregunta mine), in those intruded into hornblende-schist (Parvati Parameswara mine), and very exceptionally in pegmatite intruded into the schistose quartzite (Velaga Venkateswara mine). The probable explanation, according to Dr. P. K. Ghosh, of the selective distribution of the pegmatites (*i.e.*, their bias for the biotite-schist zone) is that the biotite-schists are the rocks least competent to withstand the tensional forces that came into play at the time of intrusion of the pegmatites. The incompetent biotite-schists and the more resistant hornblende-schists seem in this indirect way to have influenced the localisation of the pegmatites, and incidentally of the deposition of mica, for according to Dr. Ghosh, the latter would have crystallised within the walls of any 'country' provided

the pegmatitic liquid was of the requisite composition and the other conditions remained the same.

The mines being shallow (the deepest working mine, *viz.*, the Shah mine, is only 290 feet), nothing definite is known about the behaviour of the pegmatites and mica deposits in depth. The character of the pegmatites, as observed within this small range of depth, seems to vary in the different mines, and sometimes even in the same mine. Thus at the Tellabodu mine, of the two pegmatites, the lower one changes its dip to the north from the original westerly direction, at a depth of 100 feet, and becomes thinner, and the mica becomes brittle; but the upper pegmatite continues in depth with its original direction of dip, and maintains the excellent character of its mica. In the Shah mine, the dip of the pegmatite changes from south-west to north-west at 200 feet, but the character of the mica improves. In some cases, the pegmatite is actually impoverished in mica-content as it is followed in depth; but the mines have never been carried deep enough to prove that richer deposits will not be found at a lower level. So far no instance is known where the pegmatite has actually pinched out, as in the Kodarma area, Bihar. At this stage of development of the mining properties in Nellore, it seems, according to Dr. Ghosh, premature to attempt to foretell the behaviour of the mica in depth; but he records that with most of the mines that have followed scientific methods of development and working, financial success has resulted.

Natural Gas.

Kathiawar, Bombay Presidency.

63. The occurrences of natural gas at Jagatia in Kathiawar and at Baroda, situated respectively to the west and east of the Gulf of Cambay were investigated some years ago by the late Captain R. W. Palmer[1], and this work was held to justify the view that the Tertiary rocks from which this gas was known or presumed to be derived underlie large parts of the Gulf of Cambay and the alluvium at the head of the Gulf.

Some 12 years ago natural gas (with saline water) was tapped, in a bore-hole at Gogha (21° 41′ : 72° 19′) in Kathiawar, and Dr. P. K. Ghosh was asked last year to investigate this occurrence.

[1] *Rec. Geol. Surv. Ind.*, LIV, pp. 26-29, (1922).

The north-east coast of Kathiawar, where Gogha is situated, is made up of Upper Tertiary strata composed of alternating calcareous, sandy and clayey beds, the latter preponderating in depth. These sediments rest on a platform of the Deccan trap basalts, and increase in thickness as the shores of the Gulf of Cambay are approached, and provide the reservoirs from which gas and water are derived. According to Dr. Ghosh, there are three water-bearing sands above the gas sand, the lowest of the water-bearing sands being immediately above the gas sand. The gas bearing stratum is 35 feet thick, and occurs at from 812 to 847 feet below the ground-level. Boring was continued through the Tertiary strata to a depth of 1,016 feet: for the first 813 feet the hole was lined with eight-inch casing; between 813 and 997 feet the diameter of the casing was reduced to six inches; and the rest of the bore-hole remained unlined. The six-inch casing was broken at a depth of 762 feet from the surface. Dr. Ghosh infers that the annular space between the eight-inch and six-inch casings is not sealed, and that it is due to this defective construction that the gas and water flow simultaneously into the bore-hole from the surrounding strata. This also gives rise to the possibility of the gas sand being invaded by water, and the gas being driven into pockets of uneconomic dimensions—a state of affairs highly detrimental to the life and the future development of a potential gas reservoir.

The gas has been issuing, presumably at a fairly high pressure, for the past twelve years. Even at the time of Dr. Ghosh's visit, the gas when allowed to catch fire, burst into steady and vigorous flames about five feet high. It is an easily inflammable gas, and according to the report of the Industrial Chemist to the Bombay Government, the total hydrocarbons calculated as methane form 81·8 per cent. and the calculated B. T. Us. per cubic foot are 870, the heat value being thus quite high. The helium content, according to Dr. Watson of the Indian Institute of Science, Bangalore, is 1 part in 8,000—too low a percentage for the gas to be of value for the extraction of helium. The 'closed' and open pressures of the gas could not be measured as it was issuing with water. However, from consideration of the depth of the gas sand below the surface, and the recorded observations of the 'closed' gas pressure of the wells in the Tertiary strata at Baroda and Jagatia, probably forming parts of the same Tertiary basin of sedimentation as Gogha, Dr. Ghosh estimates the 'closed' pressure to be 220 lbs. to the square inch at the minimum.

Careful field observations prove that the strata have been thrown into gentle E.–W. synclines and anticlines—structures highly suitable for the accumulation of gas. The gas-field supplying the Gogha output has an estimated minimum extent of 12 square miles. The porosity of the gas sand is not known, but assuming it to be 20 per cent., Dr. Ghosh estimates that the original gas content of the field was about 37,468 million cubic feet. The open-flow pressure of the gas not being known, the rate of flow cannot be determined, nor can the life of the well be predicted with certainty. There is, however, no doubt that a considerable amount of a valuable material has been allowed to run to waste, and there can be no hesitation that further escape of the gas should be prevented.

The structure of the Tertiary belt of North-East Kathiawar, so far as it was possible for Dr. Ghosh to ascertain during the time at his disposal, seems to be favourable to the accumulation of gas. In order to explore the possibility of striking fresh occurrences of gas, and to have more precise data of the extent of the gas-field, the nature of the gas sand, and the underground structure in general, further borings are necessary. Dr. Ghosh has selected six localities at which it is desirable to drill.

Petroleum.

Resident Geologist, Yenangyaung Oilfield, Burma.

64. Charge of the office of Resident Geologist, Yenangyaung Oilfield, was held by Mr. C. T. Barber until the 13th March, 1933, and by Mr. E. J. Bradshaw from the 19th March, 1933, for the remainder of the year.

Burma Oil-Fields (Amendment) Bill, 1933.

During the year the Burma Oil-Fields (Amendment) Bill, 1933, was passed by the Burma Legislative Council. The Bill has two main objects, first to ensure that control over drilling operations is exercised automatically as soon as drilling begins in any part of the province, without the need which exists under the present Act, of notifying an oilfield, before the Warden can exercise his power of control. The second is to provide that the control to be exercised shall embody a policy of conservation of gas as well as of oil, and of prevention of waste. In anticipation of the enactment of the Bill the Resident Geologist collaborated with the Warden, Burma Oilfields, in the drafting of the rules which the Local Government will be empowered to make for regulating all matters connected with or subsidiary to any operations for the winning of oil or gas or both.

The application of vacuum to wells in the Reserves and their borders at Yenangyaung.

65. The Resident Geologist was consulted on technical matters arising out of an application for a revision of the orders [1] permitting a general increase in the degree of vacuum as applied to wells producing from certain horizons within the Reserves and their borders in the Yenangyaung oilfield. In the course of a lengthy order the Financial Commissioner, Burma, concluded, *inter alia*, that within the life of a well there may be a period during which the application of a pressure lower than atmospheric may result in an increase in the ultimate recovery from that well, but that the application of vacuum before or after this period may be harmful from the point of view of recovery. As a corollary he concluded that the simultaneous application of a uniformly reduced pressure to a large number of wells which, at any given moment, are at different stages of their productive lives is normally likely to reduce the ultimate recovery from a field. On the other hand he found, on the evidence before him, that, while all wells were not affected alike, the application of a vacuum in many cases resulted in an increased rate of production, this being not necessarily always synonymous with an increase in ultimate recovery. He concluded, however, that in the case of wells which are nearing the close of their economic life, an increase in the rate of production results in an increase in the ultimate recovery from such wells since they might otherwise be plugged and abandoned. The Financial Commissioner then examined the question whether there was any areal segregation of such wells and concluded that by choosing a line running parallel to the axis of the field, an effective segregation could be made inasmuch as the great majority of the wells west of the line were small producers, while the majority of the larger wells, to which, in his opinion, the application of an increased vacuum would be premature, were situated east of this line. He therefore directed, subject to the provision that no pressure less than atmospheric should be maintained at the well head of any well producing from below the horizon of the 3,000-foot gas sand as defined in the Warden's provisional order dated the 15th August, 1927, that on and after the 1st March 1934, a vacuum of 7½ inches of mercury might be applied at the well head of wells on sites intersected by or west of a line which he defined, and that on and after the 1st September, 1934 a vacuum of 10 inches of mercury might be applied at the well head of wells on sites intersected by or west of a line parallel

[1] *Vide Rec. Geol. Surv. Ind.*, LXII, p. 38, (1929).

to and 200 feet to the west of the line already mentioned ; his object in defining a second line being to set up a barrier zone to reduce any unfair advantages that might accrue through the application of differential pressures amounting to 5 inches of mercury to wells drilled on adjacent sites.

Miscellaneous.

The proving of remunerative production in the lower sands in the north-eastern part of the Twingon Reserve resulted in the deepening of many wells in this part of the field. The resultant drilling problems considerably increased the work of the Advisory Board as the casing policy and the inspection depths for each well were prescribed by a special order in each case. Among the miscellaneous questions on which the opinion of the Resident Geologist was given were questions relating to the storage of oil at pressures other than atmospheric, to Diesel fuel oils, and to leasing.

Salt.

Salt mine at Jatta, Kohat district, North-West Frontier Province.

66. During the month of March, Mr. E. R. Gee visited Jatta (33° 18′ 30″ : 71° 17′ 30″), Kohat district, North-West Frontier Province in order to advise the authorities of the Northern India Salt Revenue Department regarding the extent and workability of the rock-salt deposits of the Jatta mine hill. The excavation of the Jatta mine was commenced in July 1925. In the middle portion of the Jatta ridge, massive grey and transparent salt, with dark bituminous bands and intercalations of red clay and soft friable sandstone was encountered, and three small chambers were excavated. Owing to the danger of roof-falls and possible instability of pillars as a result of the soft clay and sandstone bands, and also to the fact that pot-holes filled with debris were met with, the mine was closed in August, 1932.

Mr. Gee suggests that a large quantity of rock-salt probably continues in depth and to the west within the ridge, and should the authorities desire to continue the exploitation of the salt by underground mining, he is of the opinion that attempts should be made at a much lower level in order that the workable area within the Jatta anticline may be considerably increased and the danger from pot-holes avoided. He points out, however, the following factors against mining the salt underground at the present time :—

(*a*) Extra cost compared with quarry-working.

(*b*) Danger of roof-falls on account of plastic clay bands within the seams.

(*c*) Presence of large quantities of rock-salt, accessible by quarrying, in the area just to the east of the mine.

From the open quarries, the annual output of nearly four lakhs of maunds has been largely obtained. Mr. Gee is of the opinion that a reserve of salt is available for quarry development within this eastern portion of the Jatta ridge, sufficient to maintain the present output for a large number of years—probably at least half a century.

Samarskite.

67. Samarskite is recorded by Dr. P. K. Ghosh from the disused Kondandarama mica mine, near Pailapalli village (14°21′ . 79°45′), about seven miles to the N. N. E. of the Sankara mine, Nellore district, where samarskite was formerly obtained. The mineral, associated with haematite, occurs in a pocket about three feet wide and five feet deep, in the alluvium at the north-western edge of the mine. The pocket could not be traced in the horizontal direction to any appreciable extent and the quantity of the mineral is very small. The deposit is, therefore, of little economic importance.

Soapstone.

Singhbhum district, Bihar and Orissa.

68. Dr. Dunn reports several further deposits of soapstone, which are worked by the local villagers, at Bhelaipahari and two miles east of Kokara in Dhalbhum.

Dr. Dey reports similar deposits near Mahespur (22° 23′ : 86° 30′) and Burudih (22° 22′ : 86° 31′), Dongadaha (22° 21′ : 86° 34′), north-west of Khejurdari (22° 24′ : 86° 33′), and north of Digha (22° 39′ : 86° 32′). All of these deposists were worked till recently, and the two last mentioned are still being exploited.

A rock made up of soft apple-green flakes of talc resembling books of mica occurs 1½ miles west of Chirutanri (22° 24′ : 86° 34′) and on the hill-slopes east and north-east of Mahespur.

Nellore district, Madras Presidency.

69. Dr. P. K. Ghosh notes the occurrence of a deposit of talc, half a mile west of Birla Tippa (14° 12′ : 79° 44′), Nellore district. It is of the massive variety, and is rather impure, but it is quarried for the manufacture of household utensils.

Soda.

Ahmedabad district, Bombay.

70. Dr. Ghosh records that during the dry months, the alluvium along the banks of the Bokh and the Khari rivers at Parantij in the Ahmedabad district yields incrustations of sodium salts. In these efflorescence sodium carbonate preponderates and forms roughly from 43 to 59 per cent. of the material scraped from the surface. The other salts of sodium present are chiefly the chloride, with subordinate amounts of the sulphate and the bicarbonate.

The local people treat a concentrated solution of the salts, scraped from the surface of the earth, with burnt *kankar*, for the production of caustic soda.

The caustic soda solution is then mixed with the locally obtained *mohuwa* oil and the mixture evaporated to dryness; the dry product is rolled into balls or cut into cakes and sold as soap.

The process of soap manufacture by the above process is very crude, but the Bombay Government have taken the matter in hand and are offering advice for the betterment of this local industry, which is said to yield an annual income of over two lakhs of rupees.

Water.

Ranchi, Bihar and Orissa.

71. At the request of the Superintending Engineer, Public Health Circle, Bihar and Orissa, Dr. J. A. Dunn was deputed to visit Ranchi and give advice concerning sites for new wells in the compounds of the District Jail and the Ranchi Sadr Hospital.

Shahpur district, Range, Punjab.

72. During the course of field work in the Punjab Salt Range, Mr. E. R. Gee continued his observations on the water-supply of the area. The tract covered by him during the past field season included the north-western part of the Shahpur district. It may be divided into the following sub-areas:—

(i) Alluvial plains to the south of the range between Choha (32° 24′ : 72° 1′ 30″) and Golewali (32° 29′ : 71° 50′ 30″).

(ii) Villages on the scarp slopes.

(iii) Villages on the Salt Range plateau.

(iv) The hill station of Sakesar (32° 32′ 30″ : 71° 56′).

Regarding these tracts Mr. Gee comments as follows:—

(i) The plains at the foot of the scarp include the following villages—Choha (32° 24′ : 72° 1′ 30″), Warcha (32° 25′ : 71° 58′), Golewali (32° 29′ : 71° 50′ 30″) and Rukhla (32° 27′ : 71° 57′). In the case of the three former villages, the water requirements are obtained either from artificial tanks or from springs flowing from the rocks of the scarp some distance from the villages. At Rukhla (Warcha Mandi) is an efficient scheme; spring-water from the Productus Limestone outcrop about three miles up the Jarhanwala gorge being carried in a pipe-line down to the village. Other villages, situated at greater distances from the range, depend solely on artificial tanks and it is unlikely that wells, sunk in these areas, would yield supplies of sweet water. The only remedy is the installation of pipe-lines from the springs of the Salt Range scarp.

(ii) Regarding the villages situated on the scarp slopes, these are usually *dhoks* and hamlets, obtaining their water-supply from tanks or local springs.

(iii) The plateau tract of this north-western portion of the Shahpur district includes the following large villages—Khabakki (32° 37′ : 72° 14′), Mardwal (32° 36′ 30″ : 72° 10′), Anga (32° 36′ : 72° 5′ 30″), Kotli (32° 35′ : 72° 2′ 30″), Naushahra (32° 34′ : 72° 9′), Kufri (32° 32′ 30″ : 72° 5′ 30″) and Uchhali (32° 32′ : 72° 1′). These villages are situated either on the alluvium of these upland valleys or on the adjoining Nummulitic Limestones. Their supply of fresh water is obtained either from wells sunk in this alluvium or from springs issuing from the base of the Hill Limestones of the adjoining hill areas.

The water-level of portions of these valleys—as evidenced by the existence of lakes at Khabakki and near Naushahra—is very near the surface. The water of these lakes is slightly saline and unfit for consumption. Wells sunk within a short distance of them, however, tap a good supply at a shallow depth. Nearer the edges of these valleys, at Naushahra and Anga, the water-level falls to nearly 100 feet below ground-level. Perennial springs occur in the hills south of the Naushahra-Uchhali area, at points

half a mile north of Surakki (32° 31′ 30″ : 72° 8′), a short distance south of Kufri, Pattan (32° 32′ : 72° 4′ 30″), and Kuraddi (32° 32′ : 72° 3′ 30″), and also at Kotli.

The small hill station of Sakesar depends for its supply of fresh water on several springs that flow from the Hill Limestones of that area. Water is collected also in artificial tanks. After periods of excessive drought, the flow from the springs near the top of the ridge decreases very considerably and the problem of supplying the needs of the station becomes a serious one.

Geological Surveys.

Burma Circle.

73. During the field season, 1932-33 the Burma Circle consisted of Mr. E. L. G. Clegg (in charge), Messrs. C. T. Barber and V. P. Sondhi, and Drs. M. R. Sahni and L. A. N. Iyer. On Mr. C. T. Barber proceeding on leave preparatory to retirement on March 16th, 1933, Mr. E. J. Bradshaw replaced him as Resident Geologist, Yenangyaung.

Mogok Stone Tract.

74. The new four-inch to the mile maps of the Mogok Stone Tract having been completed, work was commenced by Mr. E. L. G. Clegg, Superintendent, and Dr. L. A. Narayana Iyer, Extra Assistant Superintendent, on the detailed geological survey of the area in continuation of the work started[1] by Dr. Coggin Brown and Mr. A. K. Banerji. The new sheets comprise an area bounded by the Kin Chaung on the west, by the Möngmit State on the north, by the Konsan Taung-Kyini Taung ridge and its continuation northwards on the east side of the Pinpyit villages (22° 57′ 20″: 96° 33′) on the east, and latitude 22° 50′ 45″, *i.e.*, about five miles due south of Mogok, on the south, the total area being approximately 170 square miles. The six maps into which the area is divided can for convenience be termed the De-O, Bernardmyo, Chaunggyi-Kyetnapa, Kabaing, Kyatpyin, and Mogok sheets. Of these the Chaunggyi-Kyetnapa sheet has been completed, as also have the greater portions of the Bernardmyo, Kabaing, Kyatpyin, and Mogok sheets. Although the most accessible parts of the uncompleted sheets have been geologically surveyed, these parts are also geologically the most complex, and owing to the more open and accessible nature of the country, the ones in which the most detail can be mapped. The information derived from these sheets will, it is anticipated, be

a great help in the more rapid mapping of the topographically more difficult and densely forested parts that remain to be completed.

In previous general reports[1] the recognisable types of rocks of this area have been dealt with at some length, and with the exception of the cordierite-bearing rocks all these types were recognised *in situ* during the field season. In addition amongst the basic rocks a new type was found in the Bernardmyo area consisting mostly of aegirine and scapolite.

It was found possible to recognise the following divisions of rocks :—

11. Basic and ultrabasic intrusions.
10. Hornblende-aegirine-nepheline-rocks and aegirine-scapolite-rocks.
9. Augite-granites.
8. Syenites.
7. Acid intrusive gneisses, biotite-gneisses, garnet-pyroxene-gneisses, aplites and pegmatites.
6. Quartzites.
5. Calc-gneiss series, comprising scapolite-gneisses, pyroxene-granulites and gneisses.
4. Crystalline limestones and calciphyres.
3. Biotite-garnet- and biotite-garnet-sillimanite-gneisses.
2. Garnet-gneisses.
1. Biotite-gneisses.

For mapping purposes, however, it was found necessary to combine divisions 1, 2, 3 and 7 into a group of unclassified crystalline rocks, as they alternate so rapidly and are so inextricably mixed up and inconstant. Their outcrops cannot be followed owing to the thickness of the soil cap, and it is impossible to connect up a section noted on one stream with that on an adjacent one. In this group are also included occurrences of the other groups too small to show separately on the map.

Of the calcareous suite of rocks composed of crystalline limestones, calciphyres and calc-silicate-rocks, an endeavour has been made to map crystalline limestones and calciphyres as one division and the calc-gneisses as another. Previously the calc-gneisses were shown in the group of unclassified crystallines and not with the

[1] *Rec. Geol. Surv. Ind.*, LXV, Pt. 1, p. 80-86, (1931), and LXVI, Pt. 1, p. 92-96, (1932).

limestones and calciphyres with which they are genetically related and are usually found in close association. Where the calcareous gneisses can be mapped, this has been done and boundaries inserted: in other places where they grade into calciphyres and limestones, they have been indicated by unbounded dotted areas.

The groups shown on the map are therefore:—

8. Basic and ultrabasic intrusives.
7. Hornblende-aegirine-, nepheline- and hornblende-scapolite-rocks.
6. Augite- and hornblende-granites.
5. Syenites.
4. Quartzites.
3. Calcareous gneisses.
2. Crystalline limestones and calciphyres.
1. Unclassified crystallines.

The *basic and ultrabasic rocks* consist of two main types:—(1) the Bernardmyo peridotites, and (2) a series of augite-hornblende-rocks, widely distributed but of small extent.

The peridotites of the Bernardmyo area occur in three main exposures on a N. E.-S. W. strike. The most easterly exposure lies in and to the east of Kyaukpon (Lisu) village (23° 1′ : 96° 29′). It appears to be a thin sheet of rock dipping to the south-east parallel with the hill slope, and is intersected by a thin vein of steel-grey coarse hornblende-rock. The second exposure runs south-west from immediately south of Kyaukpon (Lisu) and cuts across the 6,276-foot ridge into the Bernardmyo catchment area. This also is a sheet dipping in a south-east direction. Distant about half a mile from the south-west end of this latter exposure is a third intrusion of peridotite, which cuts Mya Taung (23° 0′ : 96° 28′), and runs northwards towards Pyaunggaung village (23° 0′ 30″ : 96° 28′). In the stone diggings situated on this exposure a north-easterly strike is visible, although in general the outcrop is seen only as a series of loose, weathered boulders. Other minor exposures occur in the Payaw Chaung Valley, and North of Kyaukpon Taung (23° 1′ : 96° 28′ 30″), both areas lying to the east of and distant about two miles from Bernardmyo (23° 0′ 30″ : 96° 27′). The peridotite is a medium- to coarse-grained holocrystalline rock consisting essentially of olivine with a subordinate quantity of pyroxene and occasion-

ally a few grains of iron-ore. Serpentinisation has started along the cracks of the olivine crystals in some specimens.

Traces of augite-hornblende-rocks can be picked up as small boulders in many of the streams of the area. The bigger exposures are found *in situ* :—(*a*) about one mile north of Chaunggyi (Konsan) (22° 58′ : 96° 30′) on the Letha Taung (23° 0′ : 96° 30′) footpath where an augite-hornblende-felspar-rock forming a sill is intruded by pegmatites; (*b*) on the south side of the pass on the Mogok-Bernardmyo road, as a black medium-grained rock, composed of hornblende, augite and a little felspar, associated with limestone; and (*c*) near Kyaukpyathat (22° 50′ : 96° 23′) as a dark coarse-grained intrusive composed of hornblende, subordinate augite, and felspar, with quartz and a little calcite. This last rock passes into the hornblende-nepheline suite of rocks.

The *hornblende-aegirine-nepheline-rocks* and the *hornblende-* or *aegirine-scapolite-rocks* occur as small minor intrusions or bands usually associated with limestones, although one small exposure noted three miles north of Kyatpyin (22° 54′ : 96° 25′) forms a marginal fringe to a syenite intrusion. The nepheline suite of rocks has been formerly recorded from the Sinkwa road, but work to the west by south shows this suite to have a much greater extension.[1] One specimen from the type locality on the Sinkwa road a quarter of a mile north-east of the north end of Sinkwa village (22° 54′ 30″ : 96° 23′) is a medium- to coarse-grained rock consisting of a dark greenish brown hornblende with interstitial calcite, nepheline, sphene, and iron-ore, whilst from an adjacent locality augite is also found in association with the hornblende.

The pyroxene-scapolite-rocks appear as a few small exposures in the Bernardmyo vicinity. They are medium- to coarse-grained rocks mostly composed of deep green aegirine with large crystals of scapolite, a little felspar, calcite, apatite and iron-ore.

The *syenites* occur as two main intrusions, one of which around the village of Ongaing (22° 56′ : 96° 30′) has been previously mentioned; the other forms the big hill comprising the village of Bernardmyo and the high ground north of it, the southern boundary being the alluvium of the Pyaunggaung Chaung. Other smaller occurrences were seen in the Kyatpyin sheet near Thatdutsho (22° 56′ : 96° 28′), Myeme (22° 56′ : 96° 27′), Kyauklega Taung

[1] The Sinkwa exposures are the easterly outcrops of a series of bands occurring south-west and north-east of Kyaukpyathatanauk.

(22° 56′ : 96° 26′), and half a mile north N. N. E. of Bawlongyi (22° 55′ : 96° 24′). The Ongaing occurrence is the most interesting; its petrological characters have been previously described[1] as also its laccolitic intrusive nature. Exposures in the Letnyo Taung (22° 56′ 30″ : 96° 30′ 30″) (Mogok sheet) and Kyaukthinbaw Taung (22° 57′ : 96° 30′) (Chaunggyi-Kyetnapa sheet) leave little doubt as to the intrusive relationship of the syenite towards the limestone. The Letnyo Taung limestone is a big chunk of limestone and calciphyre caught up and folded in with the syenite, the whole pitching E. 30° N. Syenite occurs on the eastern flank overlying and penetrating the limestone so as to form wedges of syenite in the limestone and also occurs as the basement rock below the precipitous western face of the spur. A similar occurrence is seen on Kyaukthinbaw Taung where the scarp of the western face includes thin bands of limestone caught up by the syenite intrusion. This main syenite occurrence extends north into the Chaunggyi valley catchment and north-westwards up the Bernardmyo road to a height of 5,800 feet. It forms the lower south and south-eastern slopes of Taungme (22° 58′ : 96° 28′); and many further occurrences of limestone similar to those noted from Letnyo Taung, although not so clear, are found in it. The Bernardmyo mass is not so well exposed; it, also, contains a number of minor exposures of limestone and calcareous gneiss.

The *augite-* and *hornblende-granites* appear to be a more acid phase of the syenitic magma. They are seen in the Kyatpyin sheet just north of Yebu (22° 55′ 30″ : 96° 29′) and in the Bernardmyo sheet in the vicinity of Kyauksin (22° 57′ : 96° 26′), whilst the pegmatite seen overlying the limestone at the Kyatpyin view point (22° 54′ : 96° 24′) also appears to belong to this category.

Quartzites are found only in the Kabaing sheet, although a small exposure of vein-quartz in the Kyatpyin sheet half a mile south-west of Kyauksin has also been mapped. The quartzites of the Kabaing area are either of a replacement or sedimentary nature. They occur in association with calcareous gneiss, one north of Myainggyi Chaung, and the second mostly on the south side of the Mogok-Thabeitkyin road between miles 45 and 47. The first band mentioned passes imperceptibly into calc-granulite

[1] *Rec. Geol. Surv. Ind.*, LXV, pp. 81-82 and 86, (1931); and LXVI, pp. 94-95, (1932).

at its north-easterly end, whilst the southerly one shows highly jointed cliff exposures, is more coarse-grained than the former, and includes cavities in which sericite and some magnetite are present.

The *limestones*, *calciphyres* and *calcareous gneisses* are practically always found in association and grade from one into the other. There are, however, places in which only limestone is found and others in which calcareous gneiss appears alone. At first sight they appear to be more or less discontinuous bands following a general E. 30° N. strike, thus conforming to the general strike of the 'country' rocks. But from a survey of the sheets mapped, it seems probable that these separate exposures represent once continuous calcareous strata, the present separation of the exposures being due to the combined effects of intrusion by syenitic and granitic rocks, of folding, and of denudation. The manner in which the plutonic rocks have eaten into the base of the limestone is well illustrated in the Uyin Chaung valley, on the south-eastern slopes of Chinthe Taung (22° 56′ 30″ : 96° 26′) and the north-eastern slopes of Pingu Taung (22° 54′ 30″ : 96° 25′) in the Kyatpyin sheet, whilst folds are seen in the limestones west of Pankwe (23° 1′ : 96° 31′) and Letha Taung in the Chaunggyi-Kyetnapa sheet and also in the Mogok valley north-east of Myenigon. (22° 55′ 30″ : 96° 31′). An E. 30° N. pitch of the limestones seems to point to a similar pitch for the whole area. This pitch is well seen at Myenigon and Onbin-Yedwet Taung (22° 56′ 40″ : 96° 32′) in the Mogok sheet and probably better, west of Kyetnapa (23° 2′ : 96° 31′) and at Pinpyit in the Chaunggyi-Kyetnapa sheet. At Pinpyit a heart-shaped mass of granite with accompanying pegmatites projects through and is entirely surrounded by either limestone or calcareous gneiss, whilst the scarp at the western end of this Pinpyit exposure appears to have been faulted by an intrusion. At the base, the limestone suite has been penetrated by tongues of plutonic rock, sometimes approaching *lit par lit* injection, whilst breaking across the bedding has in some cases led to the isolation and totally inclusion of masses of the limestone series.

In one place in the valley south of Mana (23° 1′ : 96° 34′) (Chaunggyi-Kyetnapa sheet) in the stream-cutting, the limestones are exposed as a series of bands in which the following alternating succession was noted :—

Limestone.
Calc-gneiss or calciphyre.
Granite.
Calc-gneiss or calciphyre.
Limestone.

These limestones pitch out further to the east and give place to quartzites near Chaungzon (23° 2′ : 96° 35′). The petrological characteristics of the limestones 'calciphyres' and calc-gneisses will be found in the General Reports for 1930 and 1931.[1]

Prof. Adam's [2] statement that the limestones and gneisses exposed continuously from Thabeitkyin (22° 53′ : 96° 1′) to Mogok (22° 55′ : 96° 33′) strike north and south is not borne out in general in the Mogok-Thabeitkyin area. Possibly Prof. Adams made this general statement from two or three local exposures or by mistaking pitch for strike. North of Kathe (22° 54′ 30″ : 96° 26′), for instance, a north-south strike of the limestone is visible for a short distance in the continuous exposure which runs north by east through Pyaungbyin (22° 55′ 40″ : 96° 26′ 20″), due east through Bawpadan (22° 56′ : 96° 27′ 30″), and then south of east into the Yebu valley. The easterly pitch of the Letnyo Taung limestone also give this false impression of a north-south strike.

In the *unclassified crystalline* group of rocks are included all types of such small extent and rapid variation and so much obscured by weathering and soil cap that it was impossible to map them separately. Later when the whole area is completed, it will probably be possible to show the big mass of the Kabaing granite and other similar though smaller granitic intrusions separately on the map. In general these unclassified crystalline rocks appear to be the metamorphosed derivatives of argillaceous and arenaceous sediments which have been intruded along their planes of schistosity by a series of granites, syenites and pegmatites. They consist of biotite-granites, garnet-granulites or gneisses, garnet-sillimanite-gneisses, and biotite-garnet-sillimanite-gneisses, together with intruded aplites, pegmatites and granites. South of a line running E. 30° N. through Mogok, the former types appear to predominate, whilst north of this line the intrusive rocks play a much more important part.

[1] *Rec. Geol. Surv. Ind.*, LXV, pp. 82-83, (1931); and LXVI, pp. 92-96, (1932).
[2] *Bull. Can. Inst. Min. Met.*, 166, pp. 234-5, (1926).

The garnet-granulites near Mogok are very much weathered and everywhere intruded by veins of pegmatite. Prof. Adams considers them to be a series of 'highly altered and granitised sedimentary rocks.' Mr. Banerji records that the ridges south-east of Mogok valley known as Nankaung Taung, and Zalatni Taung south-west of Mogok are formed of these rocks. In the Chaunggyi-Kyetnapa sheet, south-east of the Chaunggyi valley, garnet-biotite-gneiss and garnet-gneiss are predominant. On the north side of the Chaunggyi valley, intrusives are more in evidence, the rocks varying from acid to intermediate in composition and coarse to medium in grain, but west and south-west of Letha Taung garnet-biotite-gneisses with intruded acid pegmatites again predominate. Some of these garnet-gneisses, which also contain pyroxene, may be analogous to leptynites or garnet-granulites. In the south-east corner of the Bernardmyo sheet the prominant mass of Taungmo is a biotite-gneiss intrusion. But between this intrusion and the Bernardmyo syenite intrusion, garnet-sillimanite-gneisses occur in local patches.[1]

In the western part of the area the Kabaing granite gives a characteristic topography and probably has a wide extension to the north and north-east. This is a distinct biotite-granite of a uniform character and appears to be the most recent of the acid intrusions.

Northern Shan States.

75. Dr. Sahni continued the survey of the Northern Shan States, completing the remaining portions of sheets 93 E/9 and 93 E/14 and, with the exception of a small area in its north-western corner which lies in Chinese territory, the whole of sheet 93 E/13. The present field season's work practically completes sheet 93 E.

The following succession of rocks is met with in the area surveyed :—

4. Alluvium.	Recent to Sub-recent.
3. Nam Yau series	Middle Jurassic (Bathonian).
2. Plateau Limestone	Devonian to Permian.
1. Chaung Magyi series	Pre-Cambrian.

The *Chaung-Magyis* form a belt of varying width striking N. E.–S. W. and constitute the oldest sedimentary rocks in the area. They consist of grey and purple unfossiliferous sandstones, slates,

[1] Since this went to Press I have visited the Bernardmyo tract with Mr. Clegg and I find that some of the garnet-sillimanite-gneisses are identical with Khondalite —L. L. F.

quartzites, and greyish white phyllites and generally dip at high angles: they were considerably folded and crushed before the overlying formations were deposited. They are of Cambrian or Pre-Cambrian age, being usually regarded as the latter.

The *Ordovician and Silurian* formations are absent and are probably overlapped by Plateau Limestone, since further south[1] these formations have been met with underlying the Plateau Limestones in the core of a dome-shaped fold.

The dolomites of the *Plateau Limestone* also form a narrow belt of rock with a similar N. E.-S.W. strike. The beds generally dip at low angles indicative of gentle folding. The only fossil found in them was a fusulinid allied to *Schwagerina.*

The equivalents of the *Namyau series* constitute the most fossiliferous formation in the area and their age is therefore known with certainty. Dr. Sahni found a number of new fossiliferous localities, which yielded several lamellibranchs not previously found in the area. The list of fossils collected is given on page 21.

The presence of *Holcothyris* and *Burmirhynchia* proves a Middle Jurassic (Bathonian) age for these beds.

To the east the Jurassic rocks are brought against the Chaung-Magyi series by a fault, while to the west they overlap on to the Plateau Limestone.

In addition to the above stratigraphical succession, there exists an enormous mass of granite intrusive into the Chaung-Magyi series. It forms a part of the Tawng Peng granite and among the rock types associated with it are (1) coarse-grained biotite-granite, (2) quartz-felspar-porphyry, (3) sericite-schist, (4) muscovite-granite, (5) mica-schist, etc.

Southern Shan States.

76. Mr. V. P. Sondhi continued the geological survey of the Southern Shan States on which he has now been engaged for three field seasons; and in the period under report he completed the survey of sheet 93 H/1 and the greater part of sheet 93 C/16. A short description of the rocks found in sheet 93 H/1 is included in the paper entitled 'The Geology of the country between Kalaw and Taunggyi, Southern Shan

[1] General Report for 1932, page 45.

States '.[1] In sheet 63 C/16 the following rock formations were met with :—

Alluvium	Recent.
High-level stream deposits	Sub-Recent to Pleistocene.
Upper Plateau Limestone	Permo-Carboniferous.
Lower Plateau Limestone	Devonian-Carboniferous.
Graptolite beds	Silurian.
Orthoceras beds	Do.
Hkawnghpo beds and Thitteikkon mudstone	Pindaya beds, Ordovician.
Mawson series	Ordovician.

The most important perennial stream of the area is the Zawgyi *chaung*, which rises at the foot of the Pindaya range about a mile to the west of Zawgyi village (20° 59′ : 96° 40′) in a large spring with a copious outflow. It enters sheet 93 C/16 at Mongang (21° 4′ : 96° 43′) and then follows a north-easterly course for about 12 miles through a narrow valley before it emerges on to the Lawksawk plain. The deposits of the Lawksawk plain consist of soft sandy clay with occasional layers of pebbles. These deposits are being deeply eroded owing to the rejuvenation of the Zawgyi *chaung* and in places the stream has cut a channel to a depth of 15 feet.

In the Hkawnghpo-Mongang plain, under a superficial layer of soft sandy alluvium, there exists a thick deposit of rolled bounders, clay and sand, washed down from the high ranges (as yet geologically unsurveyed) to the west, and in the neighbourhood of Mongang the bed of the Zawgyi is littered with these boulders, which convey the erroneous impression of having been brought down by this stream. Similar boulders are of widespread occurrence in the area, and are occasionally found at elevations of from 100 to 150 feet above the banks of the existing streams. Just to the north of Mongang they cover two broad hump-shaped hillocks, and indicate a period of torrential floods in sub-Recent or Pleistocene times.

Plateau Limestone occurs in a number of small exposures in the south-western quadrant of the sheet, in places resting like a cake on top of the steeply inclined phacoidal limestones of older Palæozoic age. The main outlier of this rock formation runs along the western boundary of the Mawson-Lawksawk ridge, with, it is believed, a faulted junction. It starts at the southern end of the sheet in a narrow irregular band that broadens out to its maximum width of about three miles in the latitude of Mongang. Gradually

[1] *Rec. Geol. Surv. Ind.*, Vol. LXII, Pt. 2, (1933).

narrowing it continues to the north for about ten miles before it disappears under the Lawksawk plain near the north end of the sheet. It is cut obliquely by the Zawgyi *chaung*.

For the greater part the rock is dolomitised. The pure limestones occur in local patches usually forming crags and knolls, and are at places fossiliferous. All traces of original bedding has been destroyed, so that over long stretches no dips are seen, but whenever present they are easterly.

Other outliers of the Plateau Limestone were mapped at Wan Pupas (21° 12′ : 96° 51′) extending due south as a narrow wedge between rocks of Ordovician age; and at Lawksawk, where they form the low hill crested with the Sawbwa's Haw (Palace), and the elevated rolling ground to the west of the town. Everywhere they possess the usual monotonous character peculiar to this rock formation in other parts of the Shan States.

The chief geological interest of the area covered by this sheet lies in the rocks of *Lower Palaeozoic* age which form the Mawson-Lawksawk ridge and the elevated dissected ground north and east of Hkawnghpo (Gaungpho); (21° 9′ : 96° 41′). In the southern adjoining sheet, 93 D/13, rocks of Lower Palaeozoic age were split up into (1) Orthoceras beds, (2) Pindaya beds and (3) Mawson series. In the south the outcrop of Orthoceras beds bordering the Mawson series on the west was found to terminate shortly after entering sheet 93 C/16 where it gives place to Plateau Limestone. It crops out again however about two miles further north where some excellent sections of pink phacoidal limestones are seen displaying a general anticlinal structure.

The pale fissile mudstones of the elevated ground north and east of Hkawnghpo are perhaps the local representatives of the Pindaya beds of the southern adjoining sheets but in view of certain lithological and faunal differences it has been considered better to give these the local name of *Hkawnghpo beds* until Dr. F. R. Cowper Reed has completed the examination of the fossil collections sent to him from this area.

The *Mawson series* is represented in the area under report by a dark grey, tabular, and highly jointed limestone generally showing a characteristic pattern of brownish blotches, usually irregularly disposed, but sometimes arranged roughly in lines. The brown patches resist denudation much better than the enclosing limestone so that they stick out in small irregular sharp ridges or knobs on

the weathered surface. An analysis of a sample of these showed them to be mostly argillaceous matter with some free silica.

There are three distinct outcrops of these blotchy limestones separated by deposits of mudstone and argillaceous limestone. The principal exposure of the argillaceous limestone forms the Thittiekkon (5,098 feet) range, but does not extend south to sheet 93 D/13; the next exposure to the east continues to the south forming part of the highlands north-east of Mawson, where it was mapped as a member of the Mawson series. On a detailed examination of the southern portion of the sheet 93 C/16, it became necessary to separate the argillaceous deposits of this region from the blotchy limestones and to map each of them as distinct units, as in addition to the difference in lithology must now be added a faunal difference owing to the discovery of new assemblages in the mudstones, which have no forms in common with the assemblages so far obtained from the Mawson series. Moreover, structural evidence points to a younger age for the argillaceous beds. At one place in these beds, about a mile to the south-west of hill 5,028 feet, a shale bed containing graptolites of Lower Silurian age was found in a narrow syncline.

All the three outcrops of the blotchy limestones pinch out within four miles of the southern end of the sheet and the remainder of the Mawson-Lawksawk range is built mostly of silt-stones and argillaceous limestones. Representative fossil collections from a number of points over this area have been forwarded to Dr. Cowper Reed for description.

Northern Circle.

77. During the field season 1932-33, the officers working in the Northern Circle were Dr. A. M. Heron (in charge), Messrs. E. R. Gee (Punjab), J. B. Auden (United Provinces), Dr. P. K. Ghosh (Bombay and Central India), Messrs. B. C. Gupta (Bombay and Central India), H. M. Lahiri (Punjab), and P. N. Mukerjee (Bombay and Central India).

78. Dr. A. M. Heron was in charge of the Northern Circle from his reversion to the grade of Superintendent on the 16th November, 1932, until his departure on leave on the 26th March, 1933, being succeeded by Dr. C. S. Fox. He left Headquarters for camp on the 17th December, 1932, and for the next two months was occupied in mapping the Vindhyans in the extreme east of Mewar (Udaipur State), Rajputana, the western lobe of the main Vindhyan area. For the next three weeks, until the beginning of March, Dr. Heron

worked in the neighbourhood of Nathdwara in Mewar, revising certain doubtful points in field geology, and examining the Vindhyans near Lakheri in Bundi State, mapped by Dr. A. L. Coulson. The last part of his camp-season was spent in inspecting the work of Messrs. B. C. Gupta and P. N. Mukerjee in the Panch Mahals district and the Rewa Kantha Agency, Bombay.

The Vindhyan area in Mewar had been mapped some fifty years ago by Messrs. C. A. Hacket and Kishen Singh and in Tonk, Gwalior and Indore by Mr. H. C. Jones in 1912-13 and 1913-14, but as Dr. Heron has found it necessary to make considerable modifications in the earlier mapping and as the area has never been described, he proposes to submit a paper on it for publication in the Records.

The results of Dr. Heron's visit of inspections to North Bombay are given under Petrology (page 17) and Stratigraphy (page 24).

Salt Range, Punjab.

79. During the greater part of the field-season 1932-33, Mr. E. R. Gee continued the survey of the Punjab Salt Range. The area covered by him during this period included the remaining, north-western portion of the Shahpur district and a part of the Mianwali district around Kalabagh (32° 57′ 30″ : 71° 33′) represented within portions of sheets 43 D/2, 43 D/3, 38 P/14, 38 P/15, 38 P/9 and 38 O/12.

Mr. Gee observes that the stratigraphical sequence is similar to that of the area immediately to the east, though, as in other parts of the Salt Range, lateral variation is pronounced in certain of the sedimentary groups. Of these lateral changes, he notes in particular the following :—

(*a*) The Purple Sandstones are absent in many sections to the south and south-west of Sakesar (32° 32′ 30″ : 71° 56′) and in the extreme western portion of the Salt Range.

(*b*) Although a large part of the Lower Palaeozoic sequence—so well represented in the eastern half of the range—is normally absent in these western areas, an important local development of these strata occurs on the west side of the Dhodha Wahan near its exit, to the south of Sakesar ridge. Here the Purple Sandstones are well-developed and are succeeded by over 100 feet of grey and purplish shales and dolomitic sandstones apparently representing the Neobolus Shale and Magnesian Sandstone series, whilst above the latter is a thick sequence

of blood-red Salt Pseudomorph beds. These Salts Pseudomorph shales and flags, locally 200 to 300 feet thick, contain cube-shaped pseudomorphs and are exactly similar in lithology to their representatives of the eastern part of the Salt Range. They include bands of impure gypsum at the base.

(*c*) The Jurassic strata thicken rapidly to the south of Sakesar and within the Mianwali district to the north-west. Sandstones and shales with numerous belemnites make their appearance between these beds and the lower Eocene laterite horizon near Lalumi (32° 32′ 30″ : 71° 52′) and again around Kalabagh.

(*d*) Near Mianianwali (32° 31′ : 71° 50′) north of Golewali (32° 29′ : 71° 50′ 30″), the basal Triassic limestones are directly overlain by a thick conglomerate including many Nummulitic Limestone, some Triassic and some Productus Limestone pebbles in addition to a few of granite and quartzite. These beds are overlain by grey and green soft sandstones with orange-brown clays, very like higher Siwalik types. These relatively new beds are incorporated in the folding and faulting of the area; they indicate that considerable erosion of the Salt Range strata took place prior to the final earth-movements of late Tertiary and sub-Recent times.

Regarding the tectonics of the areas under discussion, Mr. Gee observes that the strata in the scarp-slopes are often repeated by several well-marked overthrusts. In the lower outcrops of the sequence near the foot of the scarp, Purple Sandstones usually intervene between the Salt Marl and the Speckled Sandstones, but in the higher repeated outcrops they are often missing, the Speckled Sandstones resting directly on the Salt Marl. He points out that such thrusts sometimes pass laterally into overfolds or fold-faults. He notes that along the northern slopes of the Salt Range, the Nummulitic Limestone and Siwalik beds continue to form a sharp flexure linking the Salt Range with the Potwar plateau.

Mr. Gee summarises the geology of these areas as follows:

(i) *The scarp slopes between Choha and Golewali.* (Sheets 43 D/3, 38 P/14 and 38 P/15.)

The steep slopes that form the outermost portion of the Salt Range between Choha (32° 24′ : 72° 1′ 30″) and Golewali (32° 29′ :

71° 50′ 30″) include outcrops of the Salt Marl, Purple Sandstone and Speckled Sandstone series repeated by overthrusting. At the top of the slopes these beds are usually capped by the Productus Limestones. The general strike of the rocks conforms with the topography, it being in a general westerly direction as far west as Warcha (32° 25′ : 71° 58′), beyond which it turns north-westwards.

Higher up the slopes, the strata are thrown into a succession of anticlines and synclines, often fold-faulted and following similar directions of strike. Across these upper slopes the Productus Limestones—particularly the Middle Productus beds—crop out over wide areas, whilst within certain of the synclinal and overthrust structures newer beds are involved, *e.g.*, within the Darakki (32° 27′ : 72° 2′ 30″) and Nanga Miana (32° 29′ 45″ : 72° 2′ 30″) synclines to the north of Choha, the Salgi Wahan thrust three miles north-west of Rukhla (32° 27′ : 71° 57′), and the overthrust synclinal just south of Amb (32° 30′ 30″ : 71° 56′). Within these latter tracts, the Triassic, Jurassic and Nummulitic beds are exposed. In the Salgi Wahan, the Nummulitics are very thin and are overlain by Siwalik sandstones, clays and conglomerates, from the base of which a black tarry oil percolates at the surface. Above this Siwalik zone, here also very thin, the Productus Limestones are repeated by thrusting.

The Kanjra range to the north of Amb consists of a complicated, fold-faulted syncline of the Productus Limestones followed by an equally sharp anticline to the north.

In addition to these structures, running roughly parallel to the general trend of the Salt Range, the area is complicated by anticlinal folds and fold-faults aligned approximately at right angles. These structures usually coincide with the deep gorges that intersect the area, so that up these gorges, the Salt Marl, Purple Sandstone and Speckled Sandstone beds are exposed for considerable distances.

Beneath the salt-bearing marl of the Choha and Rukhla (Warcha Mandi) gorges, and of the gorge just north-east of Fatehpur Maira (32° 26′ 30″ : 72° 54′), thick grey and greenish shales with gypsum occur. These shales include the bands of low-grade oil shale previously noted.[1] The marl above contains thick seams of rock-salt, some of which are well-exposed in the working of the Warcha mine.

(ii) *The Khabakki-Uchhali Plateau.* (Sheets 43 D/2 and 38 P/14.)

[1] *Rec. Geol. Surv. Ind.*, LXII, Pt. 4, p. 414, (1930).

The Salt Range plateau, including the large villages of Khabakki (32° 37′ : 72° 14′), Naushahra (32° 34′ : 72° 9′) and Uchhali (32° 32′ : 72° 1′), consists of a broad alluvial syncline within which the two latter villages are situated. This main syncline is followed to the north by a narrow limestone anticline, then occurs a second syncline filled with alluvium—in which Khabakki lake and village are situated. Beyond this second syncline is the broad Hill Limestone anticline that forms the northern edge of the Salt Range. In places, on the crest of this anticline and down the dip slopes to the north, the Kamlials crop out and are succeeded in the lower ground of the Potwar plateau by the higher Siwalik horizons.

Within the above-mentioned alluvial synclinals, in addition to the Recent alluvium, what are probably Pleistocene sandstones, clays and conglomerates occur, particularly around Bhukhi (32° 34′ : 72° 13′) and Naushahra. These latter beds rest either on a remnant of the Kamlials or directly on the Hill Limestones. They often have a steep dip, being incorporated in the folding that has affected the older rocks of the area.

In the numerous narrow ridges to the south of this alluvial area, the strata down to the Middle Productus Limestones have been thrown into alternating, sheared anticlines and synclines. These folds continue westwards into the hills to the north of the Kanjra range where they are cut out by the reversed faults that run down the right-hand slopes of the Dhodha Wahan.

(iii) *Sakesar ridge.* (Sheet 38 P/14.)

Along the south side of Sakesar ridge, the strata are again affected by complex fold-faults and overthrusts. Above the main thrust, the sequence up to the Lower Siwaliks is well exposed. The top of the ridge is formed of overfolded Hill Limestones, from beneath which the Jurassic beds crop out as inliers in the northern slopes.

(iv) *The Kalabagh-Mari area.* (Sheets 38 P/9 and 38 O/12.)

This area, intersected by the Indus river, is traversed by a N.-S. zone of fold-faulting running up the Luni Wahan to the east of Kalabagh Hill and continuing to the south of the river near Mari (32° 57′ 30″ : 71° 35′) village. To the east of this line of disturbance, Siwalik beds crop out in very considerable thickness. This eastern area is traversed by a fault running N.-S. near Ainwan (32° 55′ : 71° 37′ 30″); along this line of faulting, small outcrops of the Salt Marl are met with.

The main—Luni Wahan—fault is also marked by two prominent outcrops of the Salt Marl with rock-salt.

To the west of this fault, the sequence is very complicated. The Salt Marl, cropping out in the southern end of Kalabagh Hill and in Mari Hill across the river, appears to form a sharp syncline running N. N. W.-S. S. E. Overthrust on to the Salt Marl of Kalabagh hill are relatively thin Siwalik sandstones and clays, capped by conglomerates. The latter include pebbles of Nummulitic Limestone, Triassic and Productus Limestones. Up the slopes north of Kalabagh village, the Productus Limestone beds crop out as a result of faulting. They are followed to the north by Triassic, Jurassic, Nummulitic and Siwalik beds. As a result of considerable fold-faulting and shearing, the outcrops are complicated.

Kangra and Hoshiarpur districts, Punjab.

80. During the field season of 1932-33, Mr. H. M. Lahiri, continuing his previous season's work, mapped parts of sheets 53 A/2, A/5 and A/6, which include portions of the Kangra and Hoshiarpur districts. The geological formations met with are the same as those given for the adjoining country to the south in the General Report for 1931 (page 56). The beds mapped by Mr. Lahiri as Kasaulis in the previous season are now, in the light of further knowledge of the stratigraphy of the area, provisionally referred to the Nalagarh stage of the Lower Siwaliks. The overlying ridge-forming sandstones previously designated as the Nahans, have now been called the Sutlej stage in accordance with Dr. Pilgrim's unpublished maps.

The Sutlej stage, which on account of the hard and resistant nature of its constituent sandstones, is responsible for the more prominent ridges that traverse the area, such as the Sola Singhi and the Jawalamukhi ridges, passes quite gradually upwards into the grey sandstone and red clays of the overlying Middle Siwaliks and these latter into the Upper Siwalik sand-rock, conglomerates and boulder beds.

The Siwalik beds of the area are only sparingly fossiliferous. The fossils collected from the Middle Siwaliks include *Dinotherium giganteum* and *Hipparion theobaldi*. The only identifiable fossils from the Upper Siwaliks are an isolated tooth of *Elephas planifrons* and a tooth of *Equus*. A *Unio* bed is reported by Mr. Lahiri to occur near the boundary of the Middle and Upper Siwaliks about six furlongs to the north-west of Nandgram (31° 39′ : 76° 14′) in

sheet 53 A/2. The specimens of *Unio* obtained are, however, too poorly preserved to allow of specific identification.

The geological structure in the portions examined of sheets 53 A/5 and A/6 and in the eastern half of 53 A/2 is essentially the same as that outlined in my General Report for 1931, for the adjoining country to the south and south-east. It becomes, however, somewhat less complicated northwards on account of some of the strike-faults mapped in the country to the south dying out in the area under report. The Budsur and Kesori faults, for instance, die out near Kalesar (31° 49′ : 76° 16′) and Sanoti (31° 38′ : 76° 17′) respectively. The fault mapped on the left bank of the Kunah Khad to the west of the Gumber fault appears to merge into the latter near Har (31° 47½′ : 76° 23′) in 53 A/5. A new fault which begins from near Satlitta (31° 35′ : 76° 15′) in 53 A/6 extends north-westwards into 53 A/2 and separates the Upper Siwalik sand-rocks of the left bank of the Soan river from the terrace-forming, almost horizontal sands and clays of the Soan valley.

The flat anticline of Upper Siwalik beds constituting the Siwalik range in the western half of 53 A/2 is also broken by a strike-fault which, however, does not extend northwards beyond Theh (31° 35′ : 76° 4′). This fault runs along the north-eastern flank of the range not far below its crest and follows a markedly zig-zag course.

Mandi and Bilaspur States, Punjab.

81. A small area which was left unmapped by Dr. Pilgrim in sheet 53 A/N.E. was also geologically surveyed by Mr. Lahiri during the season. This ground lies mostly in the Mandi State but partly in the Bilaspur State and the Kangra district. The formations mapped are the Dagshais of the Sirmur series, the Nahans (Sutlej stage) and Upper Siwaliks of the Siwalik series and Older Alluvium. In the southern part of the area, the Dagshais are seen in faulted contact with Nahans on the west and these latter with Upper Siwalik conglomerates of the Sir Khad valley. Towards the north, much of the solid geology is concealed under a thick mantle of what Mr. Lahiri has mapped as Older Alluvium. From the available field evidence, Mr. Lahiri thinks, however, that the two faults noticed in the southern part coalesce into one south-west of Bhamla Rest House (31° 36′ : 76° 45′).

82. From December, 1932, to May, 1933, Mr. Auden continued his survey of the Himalayan Foothills, working in Chakrata tahsil of

the Dehra Dun district and in Tehri Garhwal State on one inch to the mile sheets 53 F/14 and 15, 53 J/3, and half-inch to the mile sheet 53 J/N.W. Blaini, Infra-Krol, Krol and Tal rocks reappear in synclinal form near latitude 30° 30′ and longitude 78° 0′, and occur continuously to the eastern edge of sheet 53 J/3. Upper Krol limestones make up the whole of the Mussoorie ridge from Banong Hill to the Landour bazar. Tal rocks crop out on Landour and along the Mussoorie-Tehri mule-track as far as mile 5. The characters exhibited by the stage in this succession are typical of those already described west of the Tons river and call for no more comment.

Dehra Dun district and Tehri Garhwal State, United Provinces.

Below the Blaini occurs the *Jaunsar series*, which Mr. Auden has provisionally divided into three stages, in ascending order:—the Mandhali, Chandpur (30° 43′ : 77° 40′) and Nagthat (30° 34′ : 77° 58′) stages. The Mandhalis consist of a complex association of limestones, grits, slates, phyllites and a boulder bed. The top of this stage is taken as the Bansa limestone, which has been a very useful mapping horizon. Above this follows the Chandpur stage, which is characterised by highly banded quartzites and phyllites, with extensive tuffs and occasional lava flows. Intrusions of dolerite are abundant in this stage, and are probably roughly contemporaneous with the tuffs. Some of the phyllites are sub-schistose, though the rocks can never be called true schists. The Chandpur stage has been traced to Nag Tibba (30° 35′ : 78° 9′).

Mr. Auden considers that there is no indication of a thrust such as would be required to separate the Mandhali and Chandpur stages if the former is regarded as equivalent to the Blaini.

The rocks of the Nagthat stage are typically made up of quartzites, sandstones, conglomerates and phyllites, of purple and green colours, and closely resemble the Jaunsar rocks of the Simla region particularly in the presence of sheared purple conglomerates. Boulder beds occur high up in the succession, near the Blaini boulder bed and limestone. This stage has been traced from the Nagthat outlier as far east as Kaudia (30° 25′ : 78° 22′).

On the north side of the Jaunsar syncline, these rocks are conformable to the underlying Chandpur stage, but towards the south, in sheets 53 F/14 and 15, they appear to transgress this stage, and, on Bhadraj Hill (30° 28′ : 77° 57′), to come almost into contact with the Mandhalis. Mr. R. D. Oldham mapped the group of rocks here called Nagthat as Mandhali, regardless of its position

relative to the Chandpur stage and of its bulk composition. Mr. Auden supposes that Oldham considered the almost identical grits and conglomerates of the two groups of rocks to be sufficient reason to accept their equivalence. Nevertheless, he points out that the Mandhali grits occur in a definite sequence, associated with limestones, and underlying the Chandpur stage, while the Nagthat stage is barren of limestones and lies above the Chandpur stage. Moreover, the thickness of arenaceous rocks in the Nagthat stage is far in excess of that in the Mandhalis. Mr. Auden believes that the simplest explanation is to suppose that there are two groups of rocks, both containing grits and conglomerates, and separated by the intervening Chandpur stage. He considers that towards the south there was elevation and erosion of the Chandpur rocks, followed by deposition of the Nagthat stage across on to the Mandhalis. The recurrence of similar rocks, throughout the geological column of this area, remains a puzzle. Mr. Auden is disinclined, however, to accept repetition by recumbent folding as an explanation of such recurrence, since he believes that the dissimilarities of the facies associations, regarded as a whole, more than outweigh individual facies resemblances. The same objection applies to repetition by thrusting.

Mr. Auden is confident that the greater part of the rocks at Chakrata and Kailana may be correlated with the Simla slates on account of the presence of concretions similar to those in the known Simla slates near Chhaosa (31° 0′ : 77° 3′). With these concretionary beds are interbedded soft mottled purple sandstones which must also belong to the Simla slates. It is possible, however, that some of the associated soft sandstones may be Dagshai. At Dabra (30° 40′ : 77° 49′), Nummulitic limestones have been found together with green shales of Subathu type and shattered vitreous quartzites, and Tertiary sedimentation may have occurred in this region up into Dagshai times.

These Simla slates with their sporadic Nummulitic beds are separated from the Mandhalis by the southward-dipping Tons thrust, which has been traced eastwards to Sindhol (30° 37′ : 78° 05′).

Palanpur State, Mahikantha Agency, and Ahmedabad district, Bombay.

83. During the earlier part of the season, Dr. P. K. Ghosh completed the survey of the Palanpur State in North Bombay commenced in the previous field season, and also mapped the adjacent area in the Mahikantha Agency states of Sudasna, Umbri, Bhalusana,

Satlasna, Hadol and Valasna, on sheets 46 A/9 and 13 and 45 D/12 and 16; and in the Parantij division of the Ahmedabad district on sheets 46 A/11 and 15 and 46 A/10 and 14.

The formations met with were alluvium, the Jalor or Idar granite, the Erinpura granite, calc-schist (Delhi), and fine-grained granite-gneiss. The *granite-gneiss* is found at the boundary of Danta State and the small states of Umbri and Bhalusana. It is a finely banded biotite-granite-gneiss, and agrees in character with some of the fine-grained varieties of Mr. N. L. Sharma's 'granitoid and schistose gneisses' described in connection with the geology of the Danta State.[1] According to Dr. Ghosh, this gneiss is definitely older than the Erinpura granite, as it is found as inclusions therein. Owing to the lack of exposures, its relationship to the calc-schists, the oldest sedimentary rocks of this locality, is not known. Dr. Ghosh, however, provisionally regards this gneiss as pre-Delhi in view of the fact that nowhere in the whole of western Rajputana have the Delhis so far been found to be intruded by a granite older than the Erinpura granite. Similar pre-Delhi gneiss has been found by Dr. A. M. Heron in Jodhpur State, to the north-east.

Panch Mahals, Central India Agency and Rewa Kantha States Agency.

84. During the field season of 1932-33, Mr. B. C. Gupta, in continuation of the previous season's survey, worked on the one-inch sheets 46 E/12 and 16, F/9 and 13, F/10 and 14, J/4 and 8 and J/2 and 7, the area surveyed comprising portions of the Dohad and Godhra taluks of the Panch Mahals district, portions of Jhabua and Alirajpur States of the Central India Agency, the Panam valley of Bariya State, Sanjeli State in its entirety and the major portion of Lunavada State, all in the Rewa Kantha States Agency.

The oldest rocks consist mainly of slaty, phyllitic and micaceous schistose formations in the north, and a *biotitic granitic gneiss* in the south. The junction of the schistose and the gneissic formations is not very well defined: thus no gritty or conglomeratic formation has been observed anywhere at the junction, which has been closely followed for a length of nearly 50 miles. On the other hand, development of garnets has been frequently noticed in the phyllitic Aravalli schists along their contact with the gneiss. The junction is, therefore, thought to be one of eruptive unconformity.

The argillaceous formations of the northern portion of this

[1] *Quart. Journ. Geol. Min. Met. Soc. Ind.* III, pp. 22-23, (1931).

tract have a general northerly strike and are continuous with the *Aravalli* formations mapped farther north in Rajputana.

The gneissic formation near its junction with the Aravalli schists generally shows an assemblage of highly foliated biotitic gneiss and more or less gneissose granite along with veins of aplite, pegmatite and quartz. Farther south, however, the complexity gradually diminishes and the intrusive is a homogeneous, pink or grey, medium-grained granite. Discontinuous lenticles of dark amphibolite of varying thickness are often found in close association with the gneissic complex near the junction. These show an unblended contact with the highly foliated gneiss, but are frequently intruded and blended with later intrusives, mostly aplites, pegmatites and quartz veins.

Subsequent to the formation of the Archaean schists and gneisses in the area under review, there has been a big hiatus in the chronological order. For lying unconformably on these ancient metamorphics are several barely preserved, patchy exposures of *infratrappean formations*, the best development of which has been studied in the Jhabua-Alirajpur area. The outcrops generally form horizontal shelves protruding from below the Deccan trap lavas. The maximum thickness observed is nearly 25 feet; the usual thickness, however, seldom exceeds 15 feet.

The Infratrappean series is characterised by extreme heterogeneity of composition and variability of thickness of its component beds. Instances of considerable lateral variation in the lithological characters of the beds are very common, and it is extremely difficult to draw up an accurate section of the series. The generalised section may be given as follows:—

5. Porcellanitic, cherty, chalcedonic bands, often much brecciated	3 feet.
4. Siliceous, thick-bedded limestone	10 ,,
3. Concretionary and gritty limestone	6 ,,
2. Calcareous grit	3 ,,
1. Calcareous conglomerate	4 ,,

Well preserved fossil lamellibranchs, gastropods and echinoids have been found in these Infratrappeans. These have been studied by Mr. P. N. Mukerjee, who worked in the Jhabua-Alirajpur area jointly with Mr. B. C. Gupta. The Infratrappeans of the area have been provisionally included in the Bagh beds.

Overlying the Bagh formations and often resting directly on the metamorphic basement, are the lavas of the Deccan trap. The

rock is, as usual, basalt and is either massive or finely crystalline and almost non-vesicular.

No Tertiary formations have been seen in the area. The Archaeans as well as the younger rocks have been irregularly overlain by post-Tertiary deposits of Recent and sub-Recent soils, *kankar*, etc.

85. During the field season 1932-33, Mr. P. N. Mukerjee was attached to the Northern Circle and mapped portions of the Panch Mahals district and of the adjoining States of the Rewa Kantha and Central India Agencies. The ground surveyed is included in the one-inch sheets 46 J/2 and 6, 46 F/9 and 13, 46 F/10 and 14, and 46 F/11 and 15, comprising portions of the Godhra, Kalol and Dohad taluks of the Panch Mahals district and portions of Bariya and Chota Udepur and Jambughoda (Narukot) States in the Rewa Kantha Agency, and of Jhabua, Alirajpur, and Ratanmal States in the Central India Agency.

The geological formations of the area are the Aravallis with intrusive granites, often gneissic, the infratrappean Bagh beds, the Deccan trap, and Recent and Sub-Recent alluvium and soils.

The *Aravallis* (Blanford's Champaner beds—see page 24) consist of a series of slaty and phyllitic rocks and micaceous schists with intercalations of quartzites. Conglomeratic beds, though rare, have been noticed in Narukot or Jambughoda State. Tourmaline is found associated with quartz in veins in the phyllites and schists. Haematite-quartz-rock occurs interbanded with phyllites and schists in Jambughoda, Chota Udepur, and in the Halol taluk of the Panch Mahals. The quartzite beds strike E.-W. to S. E.-N. W. Near the northern frontier of the Jambughoda State, there is a thick band of limestone, containing tremolite, associated with phyllites and schists. This limestone is the western end of the bands mapped by Mr. G. V. Hobson in Chota Udepur State.[1]

The principal intrusive into the Aravallis is a *biotite-granite* often gneissic, ranging in texture from medium to coarse-grained, and sometimes porphyritic. There must have been more than one intrusion as there are instances where the gneissic biotite-granite has been intruded by normal granite. There is also a younger intrusive phase of pegmatites and aplites. The pegmatites sometimes contain books of muscovite and tourmaline. The *infra-*

[1] *Rec. Geol. Surv. Ind.*, LIX, Pl. 24, (1926).

trappean Bagh beds which are well seen in the Jhabua-Alirajpur area consist of coarse, gritty, calcareous sandstones with cherty material resting unconformably upon the Aravallis and immediately underlying the Deccan trap in the Jhabua-Alirajpur area. The maximum thickness observed is about 25 feet, but usually is not more than ten to 15 feet.

These beds contain well-preserved marine fossils, lamellibranchs, gastropods, bryozoans and echinoids; the following species described by Stoliczka from the Cretaceous of Southern India have been provisionally identified :—*Protocardium pondicheriense*, d'Orbigny, *Cardium* (*Trachycardium*) *incomptum*, Sowerby, *Cytherea* (*Callista*) *cf. sculpturata*, Stoliczka, *Turritella* (*Zaria*) *multistriata*, Reuss, the first pair belonging to the Trichinopoly stage, and the second pair to the Ariyalur stage of the South Indian Cretaceous.

It must be noted, however, that the accepted correlation of the Bagh beds is with the Utatur stage (Albian-Cenomanian) of Southern India. If, therefore, the above identification of the four species proves to be correct and is corroborated by further material collected during the next field season's work, it would appear that the beds of Jhabua and Alirajpur mark a considerably higher horizon than the Bagh beds of the more easterly area.

Overlying the Bagh beds and sometimes resting directly on the Aravallis, are the basaltic flows of the Deccan trap. Post-Tertiary (Recent and Sub-Recent) deposits of soils, alluvium and *kankar* irregularly overlie the Archaeans and the younger formations of the area.

Southern Circle.

86. During the field season 1932-33 the officers working in the Southern Circle were Dr. C. S. Fox (in charge: Assam), Mr. H. Crookshank (Central Provinces), Mr. E. J. Bradshaw (Assam), Dr. J. A. Dunn (Bihar and Orissa), Dr. M. S. Krishnan (Bihar and Orissa), Dr. P. K. Ghosh (Madras), Mr. D. Bhattacharji (Central Provinces), Dr. A. K. Dey (Bihar and Orissa), and Mr. A. M. N. Ghosh (Central Provinces). Mr. Bradshaw was transferred to the Burma Circle in March. Dr. P. K. Ghosh joined from the Northern Circle in January.

Assam.

87. Since the systematic work in the Khasi Hills carried out by the late Captain R. W. Palmer in 1920-21, and by Mr. E. J. Bradshaw in 1924, the geological survey of Assam has been in abeyance as far as the Geological Survey of India is concerned, although large tracts occupied

principally by the Tertiary formations have been mapped by the geologists of the Burmah Oil Company in Cachar, the Naga Hills and the Lakhimpur district. As a result of my visit to the Assam oilfields in 1930, a summary of the stratigraphical results obtained by the Burmah Oil Company's geologists, with amplifications of the nomenclature originally introduced by F. R. Mallet, has now been published[1] in an important paper by Mr. Percy Evans.[2] The Company prefers to treat the relevant maps as confidential for the present. In resuming the systematic geological survey of Assam by my Department, it has been decided first to complete the geology of the western parts of Assam, namely the Garo, Khasi and Jaintia Hills and their southern fringes, and then to work eastwards to the country surveyed by the oil company's geologists.

88. This work has been entrusted to Dr. C. S. Fox, and as the area in Assam still requiring survey is enormous, and progress must in many parts be slow on account of the dense jungle, it is hoped to transfer to this area additional geologists as they become available on the completion of work elsewhere. During the season under review, Dr. Fox mapped portions of the Garo Hills and adjoining areas of the Goalpara district, whilst Mr. E. J. Bradshaw spent some three months in the Khasi and Jaintia Hills mapping in continuation of his work of 19_3-_4, until his transfer to the Burma Circle in March, 1933.

Dr. Fox left for the field on the 19th November, 1932, and returned to headquarters on the 30th March, 1933. His mapping was largely confined to the north-western area of the Garo Hills (sheets 78 G/N.E. and 78 K/N.W., one inch=two miles) and a small area south of Tura (25° 31′ : 90° 15′) on sheet 78 K/S.W. Dr. Fox included in his field work the elucidation of several reputed coal discoveries in the alluvial tracts bordering the Garo Hills in the Goalpara district. These supposed coal occurrences are marked on some of the old maps in the vicinity of Phulbari (25° 54′ : 90° 3′), Rajabala (25° 45′ : 89° 59′), and several places between Singrimari (Halladaygunj ; 25° 44′ : 89° 55′) and Makrikola (25° 39′ : 89° 57′). A brief reference to these occurrences has been made in Dr. Fox's memoir on the Lower Gondwana Coalfields of India.[3]

Garo Hills.

[1] *Rec. Geol. Surv. Ind.*, LXVI, p. 82, (1932).

[2] 'Explanatory Notes to accompany a Table showing the Tertiary Succession in Assam', *Trans. Min. Geol. Inst. Ind.*, XXVII, pp. 155-253, (1932).

[3] *Mem. Geol. Surv. Ind.*, LIX, p. 51, (*in the Press*).

Dr. Fox has found the following rock formations in the areas examined by him :—

Recent alluvium of the Brahmaputra, Kalo, Galwang, etc.
Detrital laterite of Goramaragiri, Jinjaram river.
Older alluvium of Rangapani and hills to south.
Miocene beds of Kherapara (and Dalu).
Oligocene (marine) sandstones of Adugiri.
Upper Eocene (marine) strata of Damalgiri.
Sandstones, pipe-clays and lignitic coal of Tura.
Laterite and kaolinised rock of Cherangiri.
Dolerite dykes of Singrimari and elsewhere.
Barakar sandstones of Singrimari.
Archaean gneisses of Tura and Ranira.

The *Archaean gneisses* cover the greater portion of the north-western area of the Garo Hills and sink into the alluvium of the Brahmaputra valley to re-appear as inliers at various places, *e.g.*, Goalpara (26° 10′ : 90° 38′), Dhubri (26° 2′ : 90°), and other areas to the north within reach of the Himalayas. The highest point of the gneisses in the Garo Hills is Nokrek, 4,633 feet (25° 28′ : 90° 20′) on the Tura range. The exposure at Dhubri is at about 120 feet in the Brahmaputra bank below the observatory. The rocks consist of a complex of pink granites, which appear to be intrusive in an older series of banded gneisses, hornblendic rocks and other foliated types. No trace, however, has so far been found of the corundum-bearing sillimanite-rocks last seen in the Khasi Hills area about Nongmaweit (25° 40′ : 91° 4′) in Nongstoin State.[1]

In view of the presence of Gondwanas in the Darjeeling and Assam Himalayas to the north and in the Peninsula to the south-west, it has long been a matter for surprise that no Gondwana rocks have been found resting on these gneissic foundations in the Assam plateau. It is consequently a matter of considerable interest that Dr. Fox has found *Vertebraria indica* in the carbonaceous shales, with lenticles of vitrainised coal, and is associated with the sandstones and grits of Singrimari. The exposure there has long been known to be a possible coal-bearing site, but the rocks were regarded as of the same age as those of Tura, and the so-called Cretaceous coalfields of Daranggiri (25° 27′ : 90° 45′) in the Garo Hills and Mawbehlarkar (25° 24′ : 91° 45′) in the Khasi Hills. On the evidence

[1] J. A. Dunn, *Mem. Geol. Surv. Ind.*, LII, Pt. 2, pp. 167-187, (1929).

of the plant fossils it is clear that the Singrimari sandstones belong to the Lower Gondwanas. Dr. Fox has assigned these measures to the *Barakar series* on the analysis of the coal which shows a proportion of volatile matter to fixed carbon of 17 to 40. This ratio is most nearly satisfied by the Lower Barakar coals of the Jharia field. Another factor of interest in this respect is the presence of dykes of dolerite cutting the beds near Singrimari. The Singrimari measures dip gently westwards under the alluvium of the Jinjaran river. They contain no workable seam of coal, but they demonstrate quite clearly the extension of the Lower Gondwanas into Assam, while the analysis of the coal suggests that a great thickness of these Gondwanas originally occurred in this locality.

The *dolerite dykes* seen cutting through the Singrimari sandstones are petrologically identical with the dolerites and basaltic lavas and dykes of the Rajmahal Hills and the Deccan trap. Similar dykes are found throughout the gneissic areas of the Garo Hills. They occur on Samding Hill near Phulbari and between Dibru Hill and Paham (25° 55′ : 90° 7′) and other places—*e.g.*, Rongmachokgiri (25° 48′ : 90° 1′)—in the north-west; again they are seen on the way up from Tura to the top of the mountain behind Tura. Dr. Fox had found similar dykes in 1931 at Songsak (25° 38′ : 90° 37′) during his traverse from Damra (25° 56′ : 90° 47′) to Baghmara (25° 12′ : 90° 39′). The exposure at Singrimari has revealed the fact that these dolerites are newer than the Lower Gondwanas. It is also clear from exposures on the road north of Tura that these dolerites are older than the Tura sandstones, which, it is suggested below, are Lower Tertiary in age rather than Upper Cretaceous as previously supposed. The interval between the Lower Gondwanas and the Lower Tertiary is characterised by two sets of basic eruptions, the Rajmahal trap and the Deccan trap, and these Assam dolerites are presumably the equivalents of one of these.

Laterite and *kaolinised* rock occur in the hills east of Rongmachokgiri and near Cherangiri. Along the motor road from Phulbari to Tura it becomes clear that the Tura sandstones overlie the laterite, which in turn covers kaolinised gneisses and even the basalt and dolerite dykes. The great laterite-forming period in India is known to have begun early in Eocene times. This laterite horizon is well established in western India, and in the north-west, at the base of the Laki series. Dr. Fox is thus inclined to the

view that the laterite horizon of the Garo Hills represents a Tertiary land surface. If this lateritic zone be taken as Lower Eocene, it follows that the Tura sandstones, pipe-clays and lignitic coals are younger, and cannot therefore be Upper Cretaceous in age as has hitherto been believed.

The *Tura series*, as Dr. Fox calls the sandstones with coal and carbonaceous shales and basal pipe-clay beds, is best studied near Tura. It was thought that these beds were undisturbed in this locality; but they are evidently faulted against the gneisses of the mountain to the west of Tura. Also, on the Dalu road about three miles south from Tura they are seen inverted, with the gneisses over them. Dr. Fox had previously found the same rocks with the coal seams of Siju in the Simsang valley, also inverted. Dr. Fox gives reasons for suggesting that these Tura sandstones may be of Eocene age. The Tura beds have previously been correlated on petrological and other, but not on fossil, evidence, with the Cretaceous rocks of the Cherrapunji-Theria Ghat area. The correlation is particularly with the Cherra sandstones, which were thought to be the uppermost of the three Cretaceous divisions originally recognised in the Khasi and Jaintia Hills.[1] The descriptions of these beds show, however, that there is room for doubt about the grouping of the topmost (Cherra sandstones) with the underlying Cretaceous. The area has not been carefully examined since, but will be mapped by Dr. Fox in the next season. It may be mentioned that Mr. P. Evans of the Burmah Oil Company has not been able to accept the lowest coals of the Mikir Hills[2] as older than Tertiary.

The *Upper Eocene* marine beds with nummulites are the westward extension of the Sylhet limestones, but the massive limestones gradually get thinner and thinner, until they are hardly recognisable in the stream under the bridge about the 6th mile from Tura on the Dalu road. Their rusty representatives are last seen about Damalgiri (25° 32′ : 90° 8′) ten miles west of Tura. The beds consist of nummulitic limestones passing into sideritic clayey limestones, full of fossils, with interbedded grey and carbonaceous shales and sandstones, often with leaf impressions, fossil wood or other plant remains. These beds appear to pass down quite conformably into the Tura series, and upwards into a series of rusty sandstones with

[1] H. B. Medlicott, *Mem. Geol. Surv. Ind.*, VII, pp. 169, 171, 181 and 183, (1871).
[2] *Trans. Min. Geol. Inst. Ind.*, XXVII. p. 168, (1932).

the casts and impressions of marine lamellibranch shells. The beds clearly extend far westwards, but as they have become less fossiliferous and more argillaceous it is difficult to recognise them with certainty near Garobadha (25° 35′ : 90° 1′). Eastwards they are easily traced across the Simsang and so to the Khasi Hills. They are found in the Upper Simsang behind the main Tura range on the coal measures (Tura series) of Daranggiri. All along the southern side of the Tura range close to the gneisses, it is quite clear that the strata have been bent and folded. Mr. P. N. Mukerjee has examined some of the fossils brought by Dr. Fox from near Marakapara (25° 26′ : 90° 15′) and other places south of Tura and considers the assemblage of about the same as those of Lower to Middle Kirthar and faunistically related to the Yaw stage of Burma.

The rusty sandstones overlying the nummulitic beds occur in the neighbourhood of Adugiri (25° 26′ : 90° 13′). Some of the poorly preserved impressions and casts of lamellibranchs from these beds have been studied by Mr. A. M. N. Ghosh, who considers that they represent forms which occur in the range from Yaw stage to Gaj. The fauna is closely similar to that found in the Nongkulang Hill sandstones.[1] These Adugiri marine beds are therefore possibly *Oligocene* in age. The whole of these strata—Adugiri and Nummulitic—is cut sharply by a W. N. W. to W. by N. south-throwing fault near Amongpara (25° 21′ : 90° 13′) a mile north of Kherapara bungalow on the Tura-Dalu road. The beds to the south dip steeply southward and consist largely of soft sandstones, but no fossils have yet been found in them except plant impressions. They appear to occupy a lower stratigraphical position than the beds containing marine fossils found near Dalu, which are from fossil evidence regarded as *Lower to Middle Miocene* in age (Burdigalian), so that the beds near Kherapara may be basal Miocene. Dr. Fox's work did not bring him into the Dalu area, so that the next higher formation mapped by him is the Older Alluvium—laterites, and soft red sandy beds with hard ferruginous masses—of Rangapani (25° 33′ : 89° 54′). These deposits cover a large area south of Rangapani and even occupy the hills in that tract. Finally, bordering the north and north-west corner of the Garo Hills are the Recent alluvial accumulations of the Brahmaputra, the Jinjaran, the Ringgi, Galwang and Kalo rivers.

[1] E. Vredenburg, *Rec. Geol. Surv. Ind.*, LI, p. 333, (1921).

Dr. Fox states that in many cases he has traversed areas previously examined by either Mr. T. D. La Touche in 1885-87 or by Mr. H. B. Medlicott several years before then, but this was necessary for connected work. His surveys have not progressed far enough for the making of any but general remarks, but it seems clear that the presence of the Tura beds with coal and overlying Nummulitic limestone in the Upper Simsang valley north of the axis of the Tura range points to block faulting. There is accumulating evidence that the whole region is traversed by such faulting, with north of west and east of north as the two main directions. The old pre-Tura lateritised surface has a northerly dip and this may indicate a corresponding tilt of the blocks of gneiss. Outliers of the Tura beds (sandstones with lignitic coal) are found in several places north of the Rangira hills, and it is from these exposures that the rounded pieces of bright lustrous coal found in the alluvium of the Ringgi, the Galwang and Kalo rivers, are derived. This means that the northern limit of the Tertiary (Eocene) deposits corresponds almost with the present northern edge of the Garo Hills. Dr. Fox regards the several outliers of the Tura series as remnants of fluviatile beds of the Eocene epoch laid down on wide muddy flats on a shelving coast with the open sea to the south and south-east. The main point is that the Assam range was probably under water during the deposition of the Tura beds.

Khasi and Jaintia Hills.

89. During a period of some three months from the beginning of December, 1932, until early in March, 1933, Mr. E. J. Bradshaw continued the geological survey of part of the Khasi and Jaintia Hills, Assam, which he had commenced in the latter part of the field season of 1923-24.[1] He completed the survey of the southern half of sheet 83 C/N.W. on a scale of one inch to two miles.

In the area surveyed the following rock systems and formations are exposed :—

4. Shillong series.
3. Granite.
2. Epidiorite intrusions.
1. Cretaceous.

The rocks of the *Shillong series* are typically arenaceous and comparatively youthful in appearance when undisturbed: but in

[1] *Rec. Geol. Surv. Ind.*, LVIII, p. 38, (1925-26).

the neighbourhood of granite or epidioritic intrusions they are metamorphosed into quartz-schists, mica-schists, and phyllites. The quartzites are often shattered, with obliteration of the structure, and it then becomes extremely difficult to map the boundary between the granite and the quartzite. The resulting boundary is exceedingly intricate and contrasts sharply with the more usual type which flows for long distances in smooth curves with scarcely an indentation of the granite into the metamorphic series.

Mr. Bradshaw does not consider that in the area mapped by him there is sufficient justification for separating the intrusive *granite* from the granite-gneiss, and considers them identical. The granite is definitely pre-Cretaceous and is younger than the rocks of the Shillong series, into which it is intruded. Though there can be little doubt of the intrusive nature of the granite it is curious how seldom it is injected into the rocks of the Shillong series. Interfoliar injection was noticed in one or two places, but on the whole there is remarkably little direct evidence of energetic intrusion; there is a very free development of mica close to the boundary, but this feature is not peculiar to its neighbourhood.

There is a considerable development of *epidioritic rocks* (Medlicott's Khasia greenstone[1]) within the area surveyed by Mr. Bradshaw, one outcrop covering some twenty-five square miles of country. As is the case with the granite, there is little difficulty in deciding that the epidioritic rocks are pre-Cretaceous and that they are intrusive into the rocks of the Shillong series. The relative age of the granite and the epidiorite is, however, still obscure. In addition to coarse epidiorite, Mr. Bradshaw noted the occurrence of dolerite, which is definitely younger than the granite but is not necessarily contemporaneous with the epidiorite.

Mr. Bradshaw does not regard the age of the outliers that have been classified by him, and by previous observers, as *Cretaceous* as having been definitely established. He points out that the rocks are unfossiliferous and that the correlation is based on lithological and structural affinities between these and undoubtedly Cretaceous strata further to the south. The rocks are mainly horizontally-bedded sandstones with conglomeratic or felspathic basal beds, sometimes resting with marked unconformity upon the upturned edges of the rocks of the Shillong series, and at other times including the weathered remains of the underlying granite.

[1] *Mem. Geol. Surv. Ind.*, VII, p. 201, (1869).

90. The officers working in Bihar and Orissa during the field season 1932-33 were Dr. J. A. Dunn, Dr. M. S. Krishnan, and Dr. A. K. Dey.

Bihar and Orissa.

91. During the field season Dr. M. S. Krishnan continued his systematic mapping of the Gangpur State and adjoining tracts of Bihar and Orissa and completed sheets 73 B/S. E. and 73 B/S. W. In addition, he also mapped a small area to the south of Manoharpur (22° 22′ 30″ : 85° 12′) in the Singhbhum district, comprised between latitudes 22° 17′ and 22° 22′ and longitudes 85° 20′ in sheet 73 F/7, and between latitudes 22° 17′ and 22° 21′ and longitudes 85° 12′ and 85° 15′ in sheet 73 F/3 in order to complete the map of South Singhbhum.

Gangpur and Bamra States; Ranchi and Singhbhum districts.

In sheet 73 B/S. W., an unmapped portion in the south-east corner, lying in the Bamra State, was finished. The part of Ranchi district falling in sheets 73 B/S. W. and 73 B/S. E. was also completed.

In the Bamra State the rocks are mainly mica-schists and micaceous quartz-schists with some lenses of amphibole-schist. All these are penetrated by veins of pegmatite and coarse granite. Some of the hornblende-gneisses found here seem to be hybrids between the basic and acid rocks.

In the Ranchi area, the western half consists essentially of granite and the eastern half of mica-schists. The line of separation between the two trends W. S. W. from Tikra (22° 30′ : 84° 43′). The granitic area, which forms the southernmost portion of the Ranchi plateau, shows bands of unfoliated as well as of foliated gneiss. The latter is a composite gneiss derived from the intimate penetration and partial assimilation of the schists by the granitic magma. The eastern portion consists of mica-schists with a number of bands of epidiorite and amphibolite. All of these have an E. N. E.-W. S. W. strike of foliation with the dip to the S. S. E. When followed in a W. S. W. direction, the whole series is found to thin down considerably, because of the high compression to which it has been subjected.

In the report for the previous season[1] the name *Gangpur series* was suggested for the succession found in the anticlinorium. The anticlinorium is in fact a highly compressed, elongated dome-shaped structure. The southern boundary of the series was taken

[1] *Rec. Geol. Surv. Ind.*, LXVII, p. 64, (1933).

as the zon of sheared conglomerate and quartz-schist passing through Raghunathpali (22° 14′ : 84° 48′) and traceable as far west as Amasranga (22° 1′ : 84° 11′) and as far east as Jaraikela (22° 19′: 85° 6′) and Kolpotka (22° 21′ 30″: 85° 5′ 30″). The northern limit is less distinct, but can be fixed along the zone extending from Sadhumunda (22° 22′ : 84° 27′) through Amko (22° 25′ : 84° 37′), Bansjor (22° 26′ : 84° 43′) and Potob (22° 26′ : 84° 53′). Along this zone there are some thin impersistent beds of quartzite, which may possibly represent the same zone as the sheared conglomerate on the south. On the west and north-east the conglomerate and quartzite zone becomes unrecognisable, but the behaviour of the older beds, such as the marbles and the carbonaceous phyllites, leaves little room for doubt that the Gangpur series forms a closed dome, except at the south-western end, where only the upper members continue on to Ghoriajor and beyond. The series to its north in Ranchi district is considered to form the upper part of the Iron-ore series, being made up of mica-schists and epidiorites.

In the Singhbhum area, the south-east corner which forms a spur of Budha Buru consists of banded haematite-jasper. The rest of the area shows phyllites and mica-schists with intercalations of basic lava flows. This is in direct westward continuation of the area mapped by Dr. L. A. N. Iyer in 1926-27, an account of which is given in the General Report for 1927 (page 99). The phyllites are of a higher grade of metamorphism than those found further east. The basic flows are now epidiorites consisting of actinolitic amphibole, zoisite, basic plagioclase, quartz and sphene. A few lenses of carbonaceous phyllites are also found in this region.

Singhbhum district.

92. Drs. J. A. Dunn and A. K. Dey continued their survey of Dhalbhum, the eastern subdivision of Singhbhum, from where they left off in 1929. The geological examination of the copper belt was completed and it now only remains to survey neighbouring portions of Mayurbhanj State, Manbhum and Midnapore to complete the maps for publication.

The rocks in Dhalbhum may be divided stratigraphically as follows :—

8. Alluvium.
7. Laterite.
6. Grits and gravels (? Late Tertiary).

5. Newer Dolerites, often uralitised.
4. Granite, granophyre.
3. Diorite.
2. Ultrabasic igneous rocks, gabbro (late intrusive phase of the Dalma suite).
1. The Iron-ore series, with Dalma volcanic flows at the top.

This general succession is similar to that already established in western Singhbhum. The diorite is an early basic phase of the granite not previously found in other parts of Singhbhum. It is usually rather fine-grained and grades to a hornblende-granodiorite and granite. The granophyre also grades to biotite-granite, and there is a possibility that two distinct periods of granite intrusion are represented in Dhalbhum.

The grits and gravels, described as *Older Alluvium* on the old maps, represent the western edge of the coastal deposits. They have taken part in certain differential movements subsequent to deposition. The amount by which the granite and schists plains have been denuded, since uplift, by the rivers which are flowing practically at base level, has suggested to Dr. Dunn a late Tertiary age for these deposits. In the absence of fossil evidence, however, this suggestion can be regarded only as a hypothesis, and this type of argument applied to other parts of India might result in extensive tracts of Older Alluvium, known from their fossil contents to be Pleistocene, being treated as of Tertiary age.

In Dhalbhum the successive stages of the *Iron-ore series* may be grouped as follows :—

4. Dalma flows.
3. Quartzite, which in the north and west is only a minor phase interbedded with phyllite and mica-schist, but becomes the dominant type to the south-east.
2. Chloritic phyllite and mica-schist, often ferruginous, with tuffs and interbedded flows, occasional sheared conglomerate and arkose; banded quartzite and chert especially near the base.
1. Mica-schist and phyllite with intercalated quartz-schist and quartz-granulite.

Only the middle to upper part of the Iron-ore series crops out in Dhalbhum, the basal conglomerate and lower shales of western Singhbhum not being represented. Combining the zones found in

south and north Singhbhum and in Dhalbhum, the following is the complete sequence from top to bottom of the Iron-ore series:—

7. Dalma lavas.
6. Quartzite (occasional conglomerate at base)—impersistent.
5. Phyllites with tuffs, lavas, limestone, conglomerate, quartzite—metamorphosed over large areas.
4. Banded hematite-quartzite.
3. Shales, phyllites, mica-schists.
2. Limestone—impersistent.
1. Basal sandstone conglomerate.

The zones are not sharply defined. No. 1, the basal sandstone and conglomerate, sometimes contains thin beds of shale. No. 2, limestone, is found only locally south of Chaibassa, and is separated from the basal sandstone by a thin zone of shale. No. 3, shales, etc., contains sandstone beds and occasional calcareous beds. No. 4, banded hematite-quartzite, is also found at different horizons in No. 5 zone. In many places No. 3 zone passes gradually into No. 5 zone. No. 6, quartzite, frequently contains intercalated shales, etc., and there is often a phyllite zone between it and the overlying lava flows of No. 7 zone.

The interbedded conglomerates of No. 5 zone suggest accumulation of the tuffs and flows under subaerial conditions. The conglomerates often contain pebbles of rock similar to the beds with which they are interbedded. Contemporaneous partial erosion of the Iron-ore series beds took place during their accumulation.

Keonjhar State.

93. During May, 1933, Dr. A. K. Dey spent three weeks in the Keonjhar State to complete the geological map of sheet 73 G/9. This piece of work was necessary for incorporating in Mr. H. Cecil Jones's memoir on the iron-ore deposits of Bihar and Orissa to be published shortly. The area examined was found to consist of granitic rocks traversed by basic dykes and having some small inclusions of Older Metamorphics.

Central Provinces.

94. The officers working in the Central Provinces were Mr. H. Crookshank, Mr. D. Bhattacharjee, and Mr. A. M. N. Ghosh. Before his departure on long leave in 1931 Mr. Crookshank had virtually completed the re-survey of the northern portions of the Satpura region including the Pachmarhi Hills. Consequently on his return from leave it was possible to commence an attack upon the considerable blank in our geological maps in Bastar State and the adjoining portions of the Madras

Presidency. No officers of this Department had visited Bastar since Mr. P. N. Bose, who surveyed portions of Bastar State in the field seasons of 1898-1899[1] and 1899-1900.[2] Mr. Crookshank commenced work in Bastar State in November 1932. During the field season Mr. A. M. N. Ghosh was attached to the Percy Sladen Trust Expedition conducted by Dr. C. A. Matley for collecting remains of fossil reptiles from the Lameta beds in the Jubbulpore district. The results of this work are discussed under Palæontology.

Bastar State.

95. During this field season Mr. Crookshank completed the mapping of one-inch sheet 65 F/9 and 13, except for a small part of the north-east corner, and the portion of sheet 65 J/1 and 5 lying between the Kaingar river and the eastern border of Bastar State. The whole of this area is comprised between latitudes 18° 45′ and 19° 0′ and longitudes 81° 30′ and 82° 10′.

The following are the rocks mapped arranged according to their age, in so far as that is known:—

Recent	Soils, alluvium, grits, etc., from old river terraces.
Cuddapah	Shales, limestones, and quartzites.
Greenstones	Including ancient sills, flows and dykes.
Quartz-breccias, granites	Including associated pegmatites, aplites, etc.
Dharwarian rocks:—	
Bengpal series	Andalusite-gneisses and quartz-schists.
Iron-ore series	Hematite-quartzites, grünerite-garnet- and cordierite-gneisses, etc.
Quartzites	Believed to be ancient sediments.

The *Cuddapahs* are a non-fossiliferous sedimentary series lying more or less horizontally on the upturned edges of the older rocks. The name Cuddapah is retained, as it has been used in the new 32-mile map of India, but, according to Mr. Crookshank, the lithology of the rocks and their freedom from intrusions of any kind suggest that they may be Kurnool rather than Cuddapah. The same remarks would apply to the Raipur limestones and Chandarpur sandstones of the Chhattisgarh basin, with which P. N. Bose regarded the Bastar rocks as equivalent; and it must be regarded as an unsettled point in Indian stratigraphical correlation whether these comparatively unmetamorphosed Purana rocks are to be regarded as Cuddapah in age, or the equivalents of the Kurnools or

[1] General Report for 1898-1899, p. 36, (1899).
[2] General Report for 1899-1900, p. 40, (1900).

Lower Vindhyans. Grade of metamorphism proves frequently to be a misleading criterion in the correlation of the pre-Cambrian rocks of India.

Basic *greenstone* dykes are found intruded in all the rocks in the area mapped, except the Cuddapahs. They vary in size from minute veins to dykes ten miles long and 200 yards wide. The nature of the rocks of which they are composed depends to some extent on the degree of metamorphism to which they have been exposed. In coarse-grained types the ophitic texture of dolerites is sometimes preserved, and patches of augite have occasionally survived, and may now be seen in the centre of large hornblende crystals. More often all trace of the original minerals and texture has disappeared, and the rock now consists of large prismatic hornblende crystals in a matrix of granular quartz and felspar.

The flows are similar to the dykes, but finer grained with quartz amygdales and open cavities. They are found as cappings to hills and ridges in the south-western part of the area mapped.

The sills are lithologically similar to the dyke rocks, and occur as very large intrusive sheets especially in the rocks of the Bengpal series in the south-western portion of the area mapped.

True *quartz-breccias* occur in a number of places in the granite and indicate post-granitic faulting. Quartz-breccias are also formed by the replacement of greenstone dykes by quartz. Usually these can be distinguished, as the greenstone is rarely completely replaced.

Over the greater part of the area mapped, especially in the western part of it, *granite* is the foundation in which all the other rocks are set. It generally underlies flat country, but it is sometimes tough enough to form rounded hill masses and irregular tors. In typical localities it is a rather coarse binary granite with little or no sign of foliation. But, in the vicinity of ridges of any of the other rocks it is, however, frequently foliated and banded. Around the edges of the older sedimentary rocks it has digested such foreign matter, and is usually very biotitic. Close to the hematite-quartzites it often contains cordierite as well.

Pegmatites are intruded in all the pre-Cuddapah rocks. They are probably a final product of the cooling granite. Some of them are much younger than the main granite mass, for they have cut the greenstones, which are themselves intrusive in the granite.

Older than the granites are numerous rocks of *Dharwarian* type and probable sedimentary origin. These Mr. Crookshank has

divided into three sections, the relationships of which to one another are unknown.

Overlying the granite in the south-east of the map and sometimes intruded by it is the first of these, an ancient sedimentary series which Mr. Crookshank terms the *Bengpal series* after a village situated in the centre of the area where it occurs. In the course of field work this series was roughly divided into two, the andalusite-gneisses and the quartz-schists. These pass imperceptibly into one another, and it is believed that the differences between them are due to the different degrees of metamorphism to which they have been exposed rather than to any difference in the nature of the original deposit of which they are the metamorphosed products.

The andalusite-gneisses everywhere abut on the granite. Their highest grade of metamorphism is reached near the contact, where such minerals as sillimanite and garnet are fairly common. On leaving the borders of the granite first sillimanite disappears, then garnet; finally andalusite becomes scarce, though it is never entirely absent.

The quartz-schists are fine-grained rocks composed essentially of quartz, biotite and muscovite. Andalusite and iron-ore are also present in very many cases. In the hand-specimen these rocks greatly resemble fine-grained micaceous sandstones, but the method of arrangement of the mica and the absence of rounded quartz grains show that they have been completely recrystallised. The name quartz-schist is not intended to signify a parallel arrangement of the mica flakes.

The second section of these Dharwarian rocks is the *hematite-quartzites*, which crop out to the west of the Bengpal rocks. The connection between the two is uncertain, but it is possible that the former are the basal members of the latter. They lie directly on the granite and have been extensively dissolved in it. Their thickness is always small, and they are always metamorphosed. In typical cases a rough zoning can be recognised. At the centre occur the banded hematite-quartzites. These are more or less surrounded by grünerite-gneisses, due it is thought to the thermal metamorphism of the quartz and hematite. Outside this zone rocks containing grünerite, cordierite, biotite, muscovite, and quartz are developed. These are believed to be hybrids between hematite-quartzites and granite. Further out still the grünerite disappears,

followed by the cordierite, and finally normal granite is reached. Garnet is often abundant in all these rocks, but does not seem to be much affected in the course of metamorphism.

Genuine stress minerals such as staurolite or kyanite are very rare in the pre-Cuddapah rocks. It is inferred that the metamorphism has been primarily thermal. This conclusion is also supported by the textures of the various rocks examined. There is evidence, however, of a later dynamic phase with resultant regressive metamorphism, for sericite and chlorite have extensively replaced all minerals formed at the period of maximum thermal metamorphism in the pre-Cuddapah rocks. Ottrelite is also commonly developed in the Bengpal series. wherever garnet has been sericitised.

The third section of the old rocks is seen in the very large *quartzite* ridges that occur in several areas. The rocks of which these are formed are mainly granular and crystalline quartzites, but locally chloritic phyllites replace the quartzites to some extent. Judging from their uniformity, and the size and continuity of their outcrops the granular quartzites are probably altered sediments. The coarsely crystalline quartz is, however, mostly secondary. The relation of these quartzites to the other pre-Cuddapah sediments is unknown.

96. Mr. D. Bhattacharji spent the field season of 1932-33 in surveying portions of the Nagpur and Umrer tahsils of the Nagpur district and of the Bhandara and Gondia tahsils of the Bhandara district, completing sheets 55 P/1 and 55 P/9 and the western half of sheet 64 C/3.

Nagpur and Bhandara districts.

The tract surveyed in the Nagpur district on sheet 55 P/1 consists of alluvium, Deccan trap and Intertrappeans. These formations showed nothing of unusual interest, the only new Intertrappean occurrence being near Kalamna (20° 45′ : 70° 3′).

Of sheet 55 P/1 only a small portion had been previously surveyed. This area lies partly in the Nagpur and partly in the Bhandara district, and is occupied by alluvium (of the Wainganga river), Vindhyans, Dharwarian rocks of both Sausar and Sakoli type, and the gneissic complex. The Vindhyans form small exposures by the Wainganga in the neighbourhood of Pauni, and are composed of gently dipping sandstone and shales with an overlying conglomerate, and a coarse gritty basal sandstone resting on steeply

dipping gneisses and schists. These rocks are deduced to be of Vindhyan age from the agreement of their strikes and general characters with the rocks mapped as Vindhyans by Mr. P. N. Datta a few miles to the south.

Sheet 64 C/3 (the Gondia sheet), depicting a portion of the Gondia tahsil of the Bhandara district, lies north of sheet 64 C/4 (the Arjuni sheet) of which the geology has already been completed by Dr. S. K. Chatterjee.

The western half of sheet 64 C/3 is occupied by the reserved forests of the Gaikhuri range forming the north-eastern corner of the Bhandara triangle of Sakoli rocks, whilst the low country to the west is composed mainly of gneisses with overlying alluvium. The Sakoli rocks with a general N. N. E. strike are partly on the northern extension of the rocks of this series recognised in sheet 64 C/4 (the Arjuni sheet) to the south already surveyed by Dr. S. K. Chatterjee, and partly on the extension of the rocks recognised in sheet 55 O/15 (the Tirora sheet), previously surveyed by Mr. D. S. Bhattacharji, of which accounts have been given in previous General Reports.[1]

The Bhandara triangle of Sakoli rocks to which so much attention has been given by Mr. Bhattacharji and Dr. Chatterji comes to a point in the Gondia sheet, and with the completion of this area Mr. Bhattacharji ventures on an explanation of the structure of the whole triangle with its exceedingly complex folding. His Progress Report is as usual beautifully illustrated and a special feature of this season's work is the collection of a series of specimens of intricately folded rocks which are held by Mr. Bhattacharji to show on a small scale structures applicable on a large scale to the Sakoli strata in the Bhandara triangle. He has also constructed a number of models to show how by intricate folding a rock may imitate *lit-par-lit* injection, and various other structures of igneous rocks.

In this report Mr. Bhattacharji has given some attention to the various types of gneisses found near Chanditola (21° 18′ : 80° 6′) about ten miles south-west of Gondia. He recognises (1) biotite-gneisses of several types according to the additional minerals such as garnet, magnetite and hornblende, (2) hornblende-gneiss, and (3) sillimanite-gneiss.

[1] *Rec. Geol. Surv. Ind.*, LXV, pp. 107-110, (1931) and LXVI, pp. 108-111, (1932).

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MALHARI VINAYAK RAO: BORN 14TH FEBRUARY, 1878: DIED 23RD DECEMBER, 1933.

It is with great regret that I have to record the death of Rao Bahadur Malhari Vinayak Rao on the 23rd of December, 1933, only a few months after his retirement from the post of Assistant Superintendent in the Geological Survey of India.

Vinayak Rao was a graduate of Madras University obtaining the B.A. degree with Geology as one of his subjects from the Central College, Bangalore, in 1900. After a short period of practical underground training in the Ooregaum Gold Mine in Mysore he joined the Geological Survey of India as a Sub-Assistant on the 26th of October, 1904. For his first field work he was posted to assist Dr. Malcolm Maclaren in his examination of the auriferous tracts of Southern India. In subsequent years Vinayak Rao was engaged on regular geological survey work in the Central Provinces, in Burma, and in the Madras Presidency. During the Great War he rendered valuable service to Government by participating in the investigation of the wolfram deposits of Lower Burma, and in recognition of his services the Government of India were pleased to promote him to the grade of Assistant Superintendent on the 6th September, 1919, and subsequently in 1920 they conferred on him the title of 'Rao Bahadur'. Vinayak Rao had not a ready pen, in consequence of which he has but one published note to his credit in the *Records* of this Department, namely on the oil shales of Mergui, in Part 3 of Vol. LIV. In 1931-32, Vinayak Rao was President of the Geological, Mining and Metallurgical Society of India, and his Presidential Address entitled 'Development of Mineral Resources of India' appears on pages 83 to 91 of Number 3 of Vol. III of the *Quarterly Journal* of that Society.

In addition to systematic survey work Vinayak Rao undertook during his service, a considerable number of investigations of economic and engineering projects, upon each of which he submitted reports that were practical in their advice and of considerable utility. Another problem upon which Vinayak Rao was engaged at intervals was the collection of Vertebrate fossils from the Siwaliks of Baluchistan and the Punjab. Finally it is necessary to make mention of one special task entrusted to Vinayak Rao. As part of an inves-

tigation to determine the amounts of silt and dissolved salts carried to the sea by Indian rivers, Vinayak Rao for a whole year took samples of silt-laden river water from two stations on the Indus some 160 miles apart in a straight line, namely Kotri and Sukkur; the samples were taken once a week during the cold weather and twice a week during the inundation season, from surface, mid-depth and bottom at selected spots on a cross-section of the river at each place. The total number of samples collected between the 22nd November, 1905 and the 22nd November, 1906, was 739. From the laboratory work subsequently carried out on these samples it is clear that Vinayak Rao discharged faithfully this monotonous but very valuable task.

For a period Vinayak Rao was attached to my own field party in the Central Provinces and I then had an opportunity of becoming well acquainted with his honesty of purpose, his devotion to work, and the friendly spirit that caused him to be liked wherever he went. In illustration of this last quality it is pleasant to recall that Vinayak Rao, Bankim Bihari Gupta and I were in camp together in December, 1911; Vinayak Rao suggested that to celebrate Coronation Day, namely the 12th of December, we should hold some village sports open to both the villagers and our servants. We three subscribed small sums for prizes and the sports were a great success, including not only the usual events, but a camel race and a specimen-trimming competition. A few days later the villagers in return provided us with a theatrical entertainment.

Vinayak Rao retired as recently as 14th February, 1933, and all those who knew him regret that he has not lived to enjoy many years of peaceful retirement.

THE KHANPUR METEORIC SHOWER. BY M. S. KRISHNAN, M. A., PH. D., A. R. C. S., D. I. C., *Assistant Superintendent, Geological Survey of India.* (With Plates 1 to 8.)

INTRODUCTION.

Time and locality of shower.

Some meteoric stones fell in Khanpur (25° 33′ 30″ : 83° 7′ 30″) and a few neighbouring villages in the district of Ghazipur, United Provinces of Agra and Oudh, between the hours of 12 noon and 1 P.M. on Friday the 8th July, 1932. A brief mention of this fact was made in the General Report of the Geological Survey of India for the year 1932.[1] It was learnt later that fragments of the same fall were recovered from Kakrapar[2] (25° 35′ : 83° 3′) in the Jaunpur district and from Karauli[3] (25° 33′ : 83° 4′) on the banks of the Gumti river in the Benares district. From the accompanying sketch-map (Fig. 1 on page 10?) showing a portion of the Survey of India sheet 63 O/2, it will be seen that all the localities lie within a radius of about two and a half miles near the junction of the boundaries of the three above-mentioned districts.

Pieces recovered.

The Geological Survey of India received[4] nine pieces of the meteorite from Khanpur on the 18th August, 1932, through the office of the Trustees of the Indian Museum. In the following table (Table 1) are given the co-ordinates of the localities from which the pieces were recovered, two pieces from the village Gauri and one each from the remaining.

[1] *Rec. Geol. Surv. Ind.*, LXVII, p. 16, (1933). Khanpur is misspelt here as Khangpur.

[2] Communication from Dr. L. J. Spencer of the Mineral Department British Museum (Natural History). It is also stated in *Nature*, Vol. 131, p. 795, (3rd June, 1933), that fragments weighing 405 gms. were presented to the Natural History Museum by the Collector of the Jaunpur district, through Mr. C. A. Silberrad. Kakrapar is here wrongly spelt as Kahrapar.

[3] *Vide infra* in the extract from the report from the Jaunpur district.

[4] A Notification—M. 1184 dated 9th June, 1925, of the Department of Industries and Labour, Government of India—states that meteorites falling in British India are the property of the Government and should be forwarded to the Geological Survey of India. Some district authorities seem to be unaware of this.

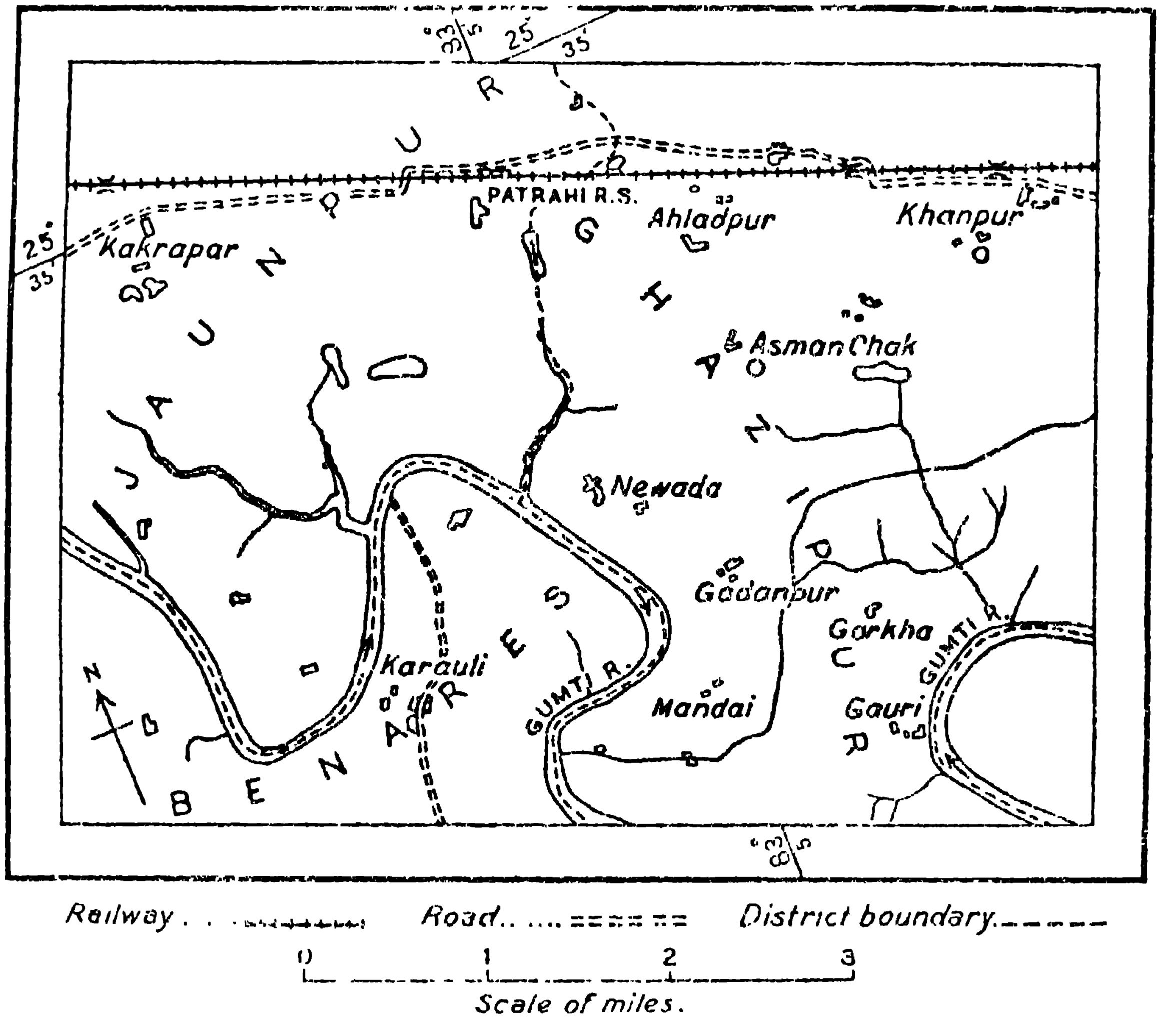

FIG. 1.—Map showing the localities at which meteorites fell on the 8th July, 1932.

TABLE 1.—*Localities from which pieces of the Khanpur meteoric shower were collected.*

Locality.	North latitude.			East longitude.		
	°	′	″	°	′	″
Khanpur	25	33	30	83	7	30
Asman Chak	25	33	15	83	6	30
Mandai	25	32	0	83	5	0
Gadanpur	25	32	30	83	5	0
Gorkha	25	32	0	83	6	0
Ahladpur	25	34	0	83	5	30
Gauri	25	31	30	83	6	0
Newada	25	33	0	83	5	0

It is almost certain that several more pieces were found by the villagers, but they have not been recovered because of the unwillingness of the people to divulge any information.

In the following table (Table 2) are given the weights of the pieces as received and at the time of their final storage, and also the specific gravities of a few. A small part of the difference in weight may be attributable to loss of moisture during storage in Calcutta, but it is mainly due to the using up of the material for study. Because of the bad packing in which they were sent to Calcutta, a certain amount of damage has been sustained, resulting in cracking and detachment of small chips.

Weights of the pieces.

In addition to the above, two pieces were received, one from Karauli and the other from Kakrapar, as late as February, 1934. Their weights are also shown in the following table. It is to be noted that the fragments weighing 450 gms. presented to the British Museum (Natural History) also belong to this fall.

TABLE 2.—*Weights of the pieces received.*

No.	Locality.	Original weight in grams.	Final weight in grams.	Specific gravity.
I	Gadanpur	877·11	(*a*) 779·14	..
			(*b*) 67·54	..
			(*c*) 23·10	..
			(*d*) 1·52	..
II	Khanpur	467·72	464·00	..
III	Newada	124·10	124·05	3·449
IV	Gorkha	113·81	113·72	..
V	Asman Chak	68·05	67·79	..
VI	Ahladpur	102·85	102·08	..
VII	Gauri	56·45	56·43	3·256
VIII	Gauri	41·02	40·93	3·409
IX	Mandai	30·05	30·01	..
X	Fragments broken during transit.	14·54	11·20	..
XI	Karauli	54·56	54·56	3·466
XII	Kakrapar	1,312·13	(*a*) 1,300·55	3·466
	Kakrapar fragments . .	..	(*b*) 11·58	..
	TOTAL .	3,262·39	3,248·20	..

The values shown in the last column but one represent the weights of the pieces at the time of the final storage in the Museum. The differences in the values of the specific gravity are probably explained by the variation in the abundance of troilite in the different pieces.

CIRCUMSTANCES OF THE FALL.

Khanpur area.

The following is an extract from the report of Mr. Sarda Prasad Saksena, Supervisor Kanungo of the Khanpur Circle, dated the 9th July, 1932:—

'On the 8th July, 1932, between 12 noon and 1 P.M., pieces of black stone fell from the sky....First there was thunder and then they fell with a whizzing sound. It is said that they were hot when they fell.'

This was followed by a more detailed report, dated the 16th July, 1932, from which the following is taken:—

Khanpur: detailed report.

'The fall of the meteorite is described in various ways in different villages and great difficulty has been experienced in obtaining fragments of the meteorite because they were appropriated by the people who thought that *surma* (a collyrium) made from them cured blindness, while others believed that it cured fire burns. People were unwilling to part with the fragments they obtained and thus concealed all sorts of knowledge they had about the meteorite.

......Debi Prasad of Beheri and Ramnath Chaube of Gorkha state that they observed the fall of the meteorite from a height of 50 yards and 20 yards respectively. The first says that the fall formed a line of smoke in the sky, but there was no luminosity, while the second says that the meteorite came as a burning ball......

The fall took place between 12 (noon) and 1 P.M., on Friday the 8th July, 1932. Only one person, Ramnath Chaube of Gorkha, says that the meteorite was seen as a burning ball of the size of ⅛ of the full moon.

The fall was noticed in eight villages—Khanpur, Gadanpur, Mandai, Gauri, Gorkha, Ahladpur, Asman Chak and Newada, where fragments were found.... Two pieces have been obtained from Gauri and one each from the remaining villages.

The fact that pieces were found in different villages within a radius of 1½ miles leads to the conclusion that the meteorite divided itself into several pieces before the fall, as all the pieces collected appear to be of the same colour and composition ..... The actual fall was accompanied by a whizzing sound ending in a heavy thud at the time of contact with the ground. The meteorite is reported to have come from the south-west and the weight is said to be from a half a seer[1] to seven seers....The evidence goes to show that it was warm when it fell.

At two places, in the villages Gadanpur and Gorkha, it fell on the tiled roofs of houses. In one case it remained on the roof and in the other it passed through and fell inside a room. In village Newada a piece fell in the river Gumti, and a piece in Gorkha in a pool. In other places it fell on open ground..... In some places the fragments did not penetrate deep into the earth where the ground was hard, while in some places they penetrated to a depth of eight inches only where the soil was soft. As it rained shortly after, the pits were filled up and were not available for observation. No change in the soil is reported on account of the fall.'

[1] 1 seer = 2·0571 pounds avoirdupois = 933·08 grams.

On receipt of the communication from Dr. L. J. Spencer, and the note in *Nature* above referred to, the authorities of Jaunpur district were requested to send their report and any available pieces. A copy of the report from the Supervisor Kanungo of the Kakrapar area, accompanied by a piece weighing 912·05 gms., was duly received. This latter may be described roughly as a triangular prism, with the three sides measuring about 115, 135 and 75 mm. respectively, and the height about 70 mm. The greater part of the surface has a fused appearance, the interior being extremely fine-grained, somewhat porous and dark grey in colour with indefinite patches of dark red-brown. Its specific gravity is 2·292. Megascopic and microscopic examination, however, shows it to be of the nature of ordinary fused brick, an opinion with which several of my colleagues agree. It seems very unlikely that the genuine meteroite could have fused such a thickness of soil, since it fell on wet ground during the height of the monsoon. The explanation seems to be that the villagers collected a piece of fused brick in mistake, in addition to the genuine meteorite which they undoubtedly collected at Kakrapar. A piece of the genuine meteorite from Kakrapar was received only in February, 1934.

Kakrapar area.

The following is extracted from the report, dated the 13th February, 1932, relating to the fall at Kakrapar :—

'The meteorite fell on the 8th July, 1932, at about 2 P.M., in village Kakrapar in a field owned by Banshlochan Chamar. The same day at the same time one more meteorite is said to have fallen in village Karauli on the bank of the river Gumti......

Kakrapar : report.

Before the fall of the stone, the sky was thunder-struck thrice and it was cloudy. When the stone fell a noise like that of an aeroplane was heard. Half of the stone sank into the ground about 12 inches deep and nearly one-half of it was still above ground. The tenants were out in the fields and they saw it falling. It was giving out smoke, and a shower of rain fell just after the fall. When the shower of rain was over, the people gathered and took away its parts. It was one piece when it fell but was broken by the people. It was about 15 seers in weight. Its dimensions were approximately $2\frac{1}{2}$ ft. long, 1 ft. wide and 1 ft. thick.

I could gather about 5 seers and sent them to *Sadr* (headquarters). The people had kept them as idols. It was easily broken and it was black in colour with particles like guinea-gold mixed in it. There was a flash of light when the stone fell. The flash of light came from the north and went to the south. It was hot when the people gathered there and broke it. They had to dig it from the earth. No more of it is available at present.'

About the fall at Karauli, the letter which accompanied the piece of meteorite from there stated :—

'The meteorite in question fell in the field of one Shyam Behari Singh of *Mauza* Karauli, *Tahsil* Benares. Before it fell, a thunderous sound was heard and on its fall the meteorite broke into pieces; smoke was seen rising up at the place where it was lying. The people of the vicinity, who had assembled there, picked up all the broken pieces and carried them away.'

Karauli.

DESCRIPTION OF THE STONES.

Description of specimens.

As mentioned above, nine pieces were received from Khanpur. The largest piece, No. I, had broken off into one large, and two small pieces, with some attendant fragments, whose respective weights are shown in Table 2. Two views, which may be called the front and back views of the largest of these, is shown in Plate 1, figs. 1 and 2. The appearance of the smaller pieces, which fit exactly on to each other, is shown in Plate 5. In the largest piece, the crust is present over about three-quarters of the surface. A portion of the fractured surface shows a greyish slickensided appearance. Several depressions and well-marked circular or oval pits, the latter 2 to 3 mm. deep, are seen on the crusted surface. The crust is black and rather shining, and shows some minute discontinuous flow-lines. The crust is very thin, being only a fraction of a millimetre in thickness.

Piece No. II is the most perfect in the collection in that it has the crust on nearly nine-tenths of the surface. The protruding edges had lost some fragments during postal transit. The piece is very irregular in shape and no indication can be found from the ill-developed flow-lines of the direction of flight of the stone. Two views of this stone are presented in Plate 2, figs. 1 and 2.

The other pieces, numbered from III to IX, and XI, are all irregular and incomplete, as the crust is present only on about a half or less of the surface of each. Their general appearance can be gathered from Plates 3, 4 and 5.

Piece No. XII, which is the largest in this collection, is shown in Plate 6, the three views being obtained by rotating the piece successively through 120° round its vertical axis.

The fractured surfaces are pale grey, nearly white. They are studded with golden yellow grains of troilite of different sizes, the

largest one measuring about 9 mm. across. No definite veins are to be seen. The mass, though compact looking, is rather soft and friable, a condition not improved by the bad packing in which the material was sent to Calcutta.

Microscopic description.

Two of the broken fragments were utilised for preparing thin sections. A general brecciated appearance is noticeable under the microscope. Radiating porphyritic and granular chondri are abundant. Besides some glassy matter, the minerals recognisable are enstatite, olivine and troilite.

Enstatite and olivine.

The enstatite makes up very finely fibrous, radiating chondri. Most of these have an eccentric structure (Plate 7, fig. 1) while some show the fibres in parallel orientation (Plate 8, fig. 2). An enlarged eccentric enstatite chondrus is seen in Plate 7, fig. 2. The olivine generally occurs in much coarser form. A porphyritic chondrus with idiomorphic crystals of olivine is seen in Plate 8, fig. 1. Much of the granular material of the sections is olivine, forming part of granular chondri. A little finely crushed material, on immersion in suitable liquids, showed that the olivine had a refractive index ranging up to a maximum of 1·705, while enstatite had a medium value of about 1·685. These values would point roughly to an olivine with about 15 per cent. of FeO and an enstatite with about 8 to 10 per cent. of FeO.

Troilite.

Troilite grains are interspersed with these. They sometimes show a tendency to be streaky. A few minute fragments, which were tested for nickel, gave a negative result.

Some glassy material is present in the interstices of the grains and fibres of olivine and enstatite. There is also some very finely crystalline material.

Name and classification.

As the pieces described here came from Khanpur and its neighbourhood, it is proposed to call them by the name of that village. They have been registered under No. 296, stone meteorite, in the collections of the Geological Survey of India. In Brezina's classification, the material is assigned to No. 16, Breccia-like White Chondrite (Cwb).

EXPLANATION OF PLATES.

PLATE 1, FIG. 1. Piece I (Gadanpur), front view.

FIG. 2. Piece I (Gadanpur), back view.

PLATE 2, FIG. 1. Piece II (Khanpur), front view.

FIG. 2. Piece II (Khanpur), back view.

PLATE 3. Pieces III (Newada), IV (Gorkha) and V (Asman Chak).

PLATE 4. Pieces VI (Ahladpur), VII (Gauri) and VIII (Gauri).

PLATE 5. Pieces I (b, c) (Gadanpur), IX (Mandai) and XI (Karauli).

PLATE 6. Three views of Piece XII, obtained by rotating it successively through 120° round its vertical axis.

PLATE 7, FIG. 1. Thin section 22,909 from Piece I, showing brecciated appearance, radiating enstatite chondri and granular olivine chondri. (× 12.)

FIG. 2. An eccentric radiating enstatite chondrus in the same section. (× 32.)

PLATE 8, FIG. 1. A part of thin section 22,909, showing an excellent porphyritic olivine chondrus near the centre. (× 16.)

FIG. 2. Thin section 22,910 from Piece II, showing finely fibrous enstatite chondrus with parallel orientation of the fibres. (× 15.)

FIG. 3. A part of section 22,910, showing a radiating olivine chondrus. (× 32.)

RECENT OBSERVATIONS ON THE CAMBRIAN SEQUENCE OF THE PUNJAB SALT RANGE. BY E. R. GEE, M.A. (CANTAB.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 9 to 11.)

INTRODUCTION.

General sequence.

In the eastern part of the Cis-Indus Salt Range, the strata that usually overlie the Salt Marl include the following :—

Salt Pseudomorph beds.
Magnesian Sandstones.
Neobolus Shales.
Purple Sandstones (at the base).

Suggested Cambrian age of suite.

Of these beds, the Neobolus Shales have, in the past, proved to be fossiliferous, the fossils including trilobites, primitive types of brachiopods, etc., of Cambrian age.[1] On account of the very close association of the overlying Magnesian Sandstones and of certain fossils discovered by Noetling, the latter were also regarded as belonging to the Cambrian, and it has been suggested by certain writers who have examined the area subsequent to Mr. A. B. Wynne's original survey, that both the underlying, unfossiliferous Purple Sandstones and the overlying Salt Pseudomorph beds, also, belong to this Cambrian suite.

Pre-Talchir erosion.

In addition, on the evidence of Wynne's work, with important later additions by Mr. C. S. Middlemiss, it has been inferred that this sequence was subjected to erosion in pre-Talchir (pre-Upper Carboniferous) times, resulting in its gradual elimination westwards in the middle and western parts of the Cis-Indus Salt Range. The Salt Pseudomorph beds were supposed to have died out near Makrach (32° 40′ : 72° 54′),

[1] Wynne, *Mem. Geol. Surv. Ind.*, XIV, Art. 1, (1878). Middlemiss, *Rec. Geol. Surv. Ind.*, XXIV, Pt. 1, (1891). Redlich, *Pal. Ind.* (New Series), Vol. I, *Mem.* 1 (1899). Walcott, *Proc. Wash. Acad. Sci.*, VII, pp. 251-256, (1905). Noetling, *Rec. Geol. Surv. Ind.*, XXVII, p. 74, (1894). Pascoe, *Mem. Geol. Surv. Ind.*, XL, Pt. 3, (1920). Fox, *Rec. Geol. Surv. Ind.*, LXI, Pt. 2, (1928). Cotter, *Mem. Geol. Surv. Ind.*, LV, Pt. 2, (1933).

the Magnesian Sandstones near the Nilawahan south of Nurpur (32° 40′ : 72° 35′), and the Neobolus Shales around Katha (32° 31′ : 72° 25′), the Purple Sandstones being absent in the western end of the Salt Range.

Overlying these various strata, the Talchir boulder bed was supposed to transgress, fairly regularly, westwards. In the eastern end of the Salt Range it overlay the Salt Pseudomorph beds, between Makrach and Katha it rested on the Magnesian Sandstones or the Neobolus Shale beds, west of Katha it was deposited directly on the Purple Sandstones, and in the western end of the Range it transgressed on to the Salt Marl series.

Transgression of Talchir boulder bed.

The pre-Talchir land-surface of the Cis-Indus Salt Range was, therefore, visualised as an area of markedly regular topography, only slightly affected by post-Cambrian earth-movements. For those who favoured an early Cambrian or pre-Cambrian age for the underlying Salt Marl series, this feature was, very naturally, an important one.

PURPOSE OF PAPER.

In the present note, evidence throwing light on certain of the above-mentioned features, is brought forward. This evidence, which has accumulated during the course of the geological survey of the Salt Range during the past five years, appears to prove:—

Evidence accumulated during present survey.

(i) The probable *correctness* of the assumption that the Magnesian Sandstones and overlying Salt Pseudomorph beds are of Cambrian age.

(ii) The *incorrectness* of the assumption that the pre-Talchir land-surface in the Cis-Indus Salt Range was an area of markedly *regular* topography.

The evidence for these two assertions is as follows:

EVIDENCE.

The pre-Talchir Land-surface.

Within several of the principal gorges that intersect the Salt Range scarp and the plateau to the north in the middle portion of the Range (*e.g.*, the Sardi, Nurpur and Katha gorges), the Talchir boulder bed, when traced northwards up these gorges, transgresses

on to lower horizons of the Cambrian sequence. This unconformable transgression is here, however, relatively gradual.

Further west around Warcha Mandi (32° 26′ 30″ : 71° 57′), however, this northerly transgression is more rapid. In the lower scarp slopes, the Talchir boulder bed rests on the Purple Sandstones, the latter being often over 200 feet in thickness, whilst not far to the north within the middle scarp slopes, where the sequence is repeated by folding, fold-faulting or by thrusting, this late Palaeozoic boulder horizon in many instances directly overlies the Salt Marl series—the Purple Sandstones being absent.

Even this evidence is, however, by no means as impressive as are certain features still further west near Chittidil (32° 29′ : 71° 54′) about five miles north-west of Warcha Mandi (Rukhla) and again at Chhidru (Chideru) (32° 33′ : 71° 46′ 30″). At these two places, important remnants of the Cambrian sequence (the Neobolus Shales, Magnesian Sandstones and Salt Pseudomorph beds) have been discovered in the course of field work during the past two years.

Details of Cambrian occurrences. The details of these two Cambrian occurrences are as follows:—

(a) The Chittidil area.

Cambrian beds near Chittidil. On the right side of the Dhodha Wahan, about 1½ miles north-east of Chittidil Rest House, the sequence includes:—

(*Talchir boulder bed*- unconformable.)

4. *Salt Pseudomorph beds*—typical red shales and flags, ripple-marked and including some cube-shaped pseudomorphs, with purple-grey gypseous shales at the base; the series attains a *local* thickness of several hundred feet.
3. *Magnesian Sandstones*—some massive, hard, calcareous and dolomitic sandstones with bands of purple-grey shale.
2. *Neobolus Shales*—purple-grey shales and sandy shales with bands of hard, calcareous, glauconitic sandstone; the usual pebble bed occurs at the base.
1. *Purple Sandstone series*—massive, jointed, maroon, and subordinate buff-coloured sandstones, with maroon shales and flags at the base; total thickness at least 250 feet.

The Neobolus Shale and Magnesian Sandstone beds are together about 175 to 200 feet thick, that is, appreciably thinner than in the

extreme east of the Salt Range. The passage from 2 to 3, and from 3 to 4, is also much more gradual in these Chittidil exposures.

Between Chittidil and Chhidru, that is, around Golewali (32° 9′ 30″ : 71° 51′), the Neobolus Shale : Magnesian Sandstone : Salt Pseudomorph sequence is absent, the Talchir boulder bed resting directly on the Purple Sandstones.

In the lower scarp slopes about $1\frac{1}{2}$ miles E. S. E. of Chhidru, however, these Cambrian beds recur locally.

(b) *The Chhidru area.*

Cambrian beds near Chhidru.

The section in the southern branch of the Khanzaman gorge is as follows :—

(*Talchir boulder bed* markedly unconformable.)

4. *Salt Pseudomorph beds* -blood-red, spotted green, shales and flags, absent in the gorge-bed, but thickening up the north-western slopes to about 45 feet. Below comes an alternating sequence of flaggy calcareous, grey-green sandstones, purple-red and greenish shales and flags, and purple-grey micaceous shales with dark purple-red, and greenish shales and flags at the base. The thickness of these lower beds is about 100 feet.
3. *Magnesian Sandstones* massive, jointed calcareous and ? dolomitic, grey sandstones and flags, alternating with purple-grey shales and sandy shales; total thickness 85 to 90 feet.
2. *Neobolus Shales*—purplish grey shales, micaceous sandy shales and micaceous, greenish grey, glauconitic sandstones alternating with subordinate flags and hard, calcareous sandstone bands. At the base occurs a three to four-foot band of yellow and white grit terminating below in the typical Neobolus Shale pebble bed. Total thickness of the series is about 105 feet.
1. *Purple Sandstone series* similar to the more easterly outcrops, including a maroon shale and flag zone at the base; total thickness of the series is about 350 feet.

In this gorge-section, the Talchir boulder bed is seen to transgress across the upper part of the Salt Pseudomorph strata, so that although the blood-red shales crop out up the north-western slopes,

they are largely absent in and around the gorge bed, the Talchir boulder bed resting directly on the lower horizons in the bed of the *nala*. This transgression occurs within the space of a few hundred yards in a N. E.-S. W. direction. Again, about three-quarters of a mile south of this gorge, and about the same distance to the north of it, the Talchir boulder bed rests directly on the Purple Sandstones, the fossiliferous Cambrian beds being absent.

Conclusion: Pre-Talchir land-surface irregular.

The occurrence of these two exposures, including representatives of the complete Cambrian sequence of the Salt Range at Chittidil and at Chhidru indicates that the pre-Talchir land-surface of the Cis-Indus Salt Range was definitely *irregular* in topography, and that the Talchir transgression was by no means so gradual a feature as has been previously supposed.

CONTINUITY OF CAMBRIAN SEDIMENTATION.

Fossils within the Cambrian sequence at Chittidil and Chhidru.

At Chittidil, trilobites and brachiopods were found in the purple-grey shales of the Neobolus Shale series, and in the similar shales that occur within the Magnesian Sandstone series not far below the Salt Pseudomorph beds.

At Chhidru, a few similar brachiopods were obtained from the purple-grey shales of the Magnesian Sandstone series, and also from similar grey shales that occur within the basal portion of the Salt Pseudomorph sequence.

Fossils identical with certain Neobolus Shale fossils.

At least some of these specimens appear to be identical with certain of the Neobolus Shale fossils that have been discovered by earlier observers in the main outcrops of the eastern parts of the Salt Range.

Conformability of sequence.

Again, the whole sequence, from the Neobolus Shales up into the Salt Pseudomorph beds, is quite conformable, and although in the eastern portion of the Range, the three divisions—Neobolus Shales, Magnesian Sandstones and Salt Pseudomorph beds—can be distinguished fairly definitely on lithology alone, at Chittidil and at Chhidru this distinction is less marked. At the latter places, the massive hard, calcareous and dolomitic sandstones of typical 'Magnesian Sandstone' type are far less prominent, and purple-grey, micaceous shales and flags, similar to those that predominate in the Neobolus Shale series,

occur within the Magnesian Sandstones and among the basal beds of the Salt Pseudomorph series.

Therefore, on lithology and the absence of any disconformity alone, one might well regard the three divisions as parts of one continuous sequence of Cambrian sedimentation. This feature appears to be borne out by the recently-discovered fossils of the exposures at Chittidil and Chhidru in the middle-western portion of the Cis-Indus Salt Range.

Conclusion : continuous sequence of Cambrian sedimentation.

EXPLANATION OF PLATES.

PLATE 9. Folded Cambrian beds forming the right slopes of the Dhodha Wahan Salt Range. The photograph shows the Cambrian sequence forming spur 2,055 feet, overlooking the Dhodha Wahan about 1½ miles north-east of Chittidil Rest House (sheet 38 P/15). Salt Marl crops out in and around the gorge bed. Above, the thick Purple Sandstone series forms steep slopes capped by the Neobolus Shale-Magnesian Sandstone strata. The latter form a sharp syncline, within which the Salt Pseudomorph beds are included.

PLATE 10. Scarp slopes south-east of Chhidru, Salt Range.

At the base of the scarp to the south east of Chhidru (sheet 38 P/14), in the right half of the photograph, Salt Marl crops out around the entrance to the Khanzaman gorge. Above, the lower cliffs include exposures of the Cambrian beds followed by more gentle slopes of Speckled Sandstone strata. The cliffs of the upper slopes (in the right half of the photograph) are composed mainly of Middle Productus Limestones. These beds, together with overlying Upper Productus, Triassic, thin Jurassic and Siwalik strata, are thrown into a sharp syncline, the eastern limb of which is considerably sheared. Among these sheared strata, the Middle Productus Limestones are again exposed as jagged cliffs seen forming the ridge and peak at the top of the scarp in the middle of the photograph.

PLATE 11. The Cambrian-Talchir boulder bed sequence south-east of Chhidru, Salt Range.

The cliff section in the lower half of the photograph shows the Cambrian suite as exposed in the right-hand slopes of the southern branch of the Khanzaman *nala*, about 1½ miles south-east of Chhidru (sheet 38 P/14).

In the lower slopes, the Purple Sandstones crop out followed above by the Neobolus Shale and Magnesian Sandstone strata. Salt Pseudomorph beds overlie the latter, the dark red shales and flags being seen in the top of this scarp section. These red shales die out to the dip, that is, down the slope towards the right-hand bottom corner of the photograph, being overlapped by the Talchir boulder bed that rests unconformably upon them.

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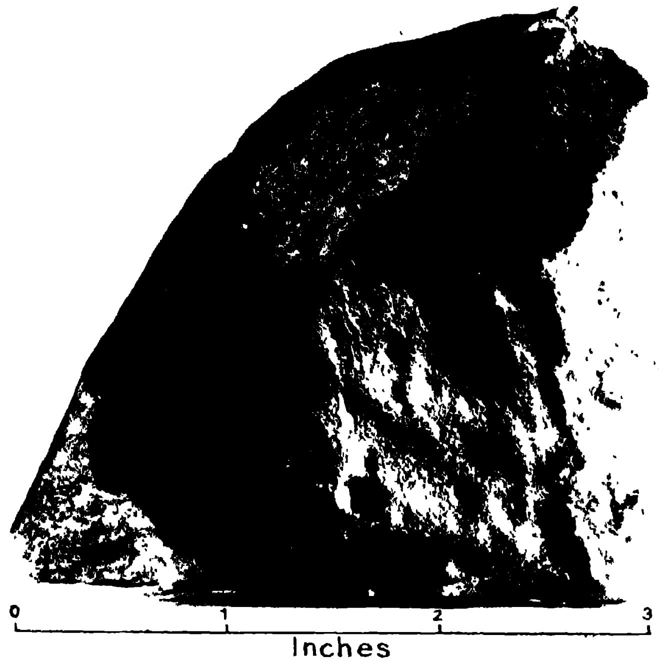

FIG. 1 PIECE I (GADANPUR), FRONT VIEW.

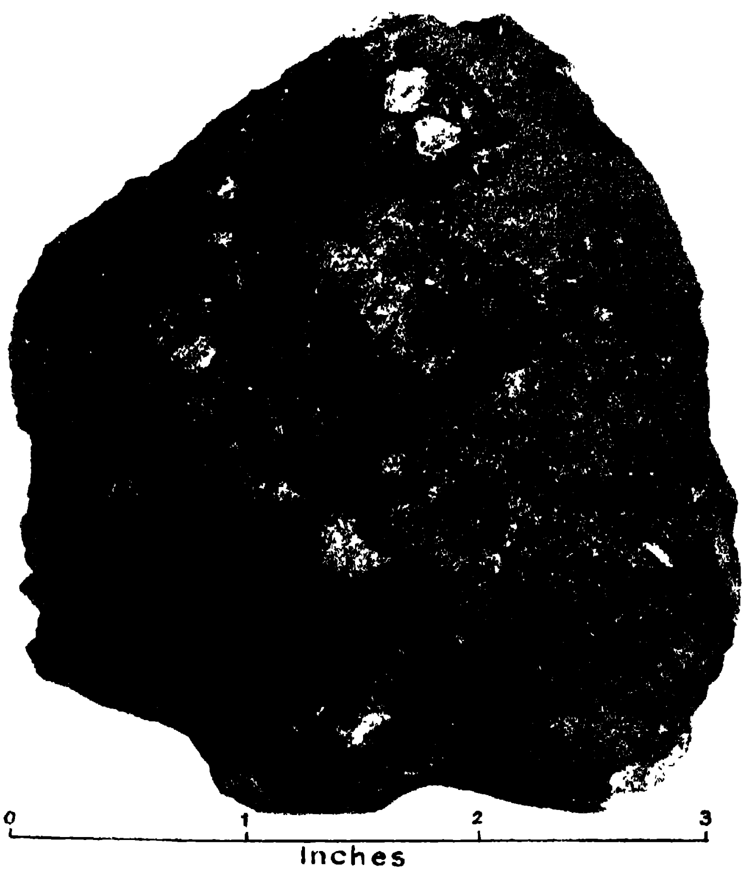

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FIG. 2. PIECE I (GADANPUR), BACK VIEW.

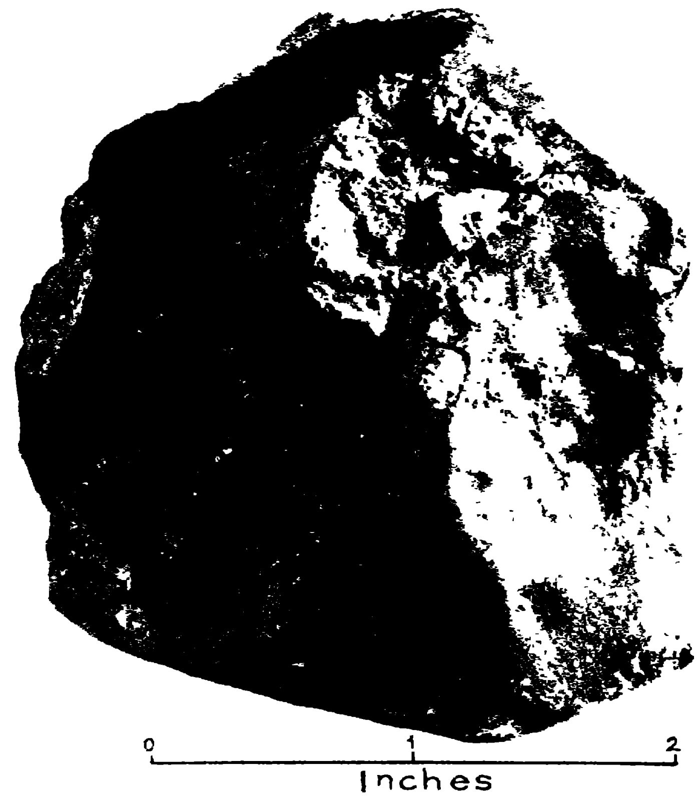

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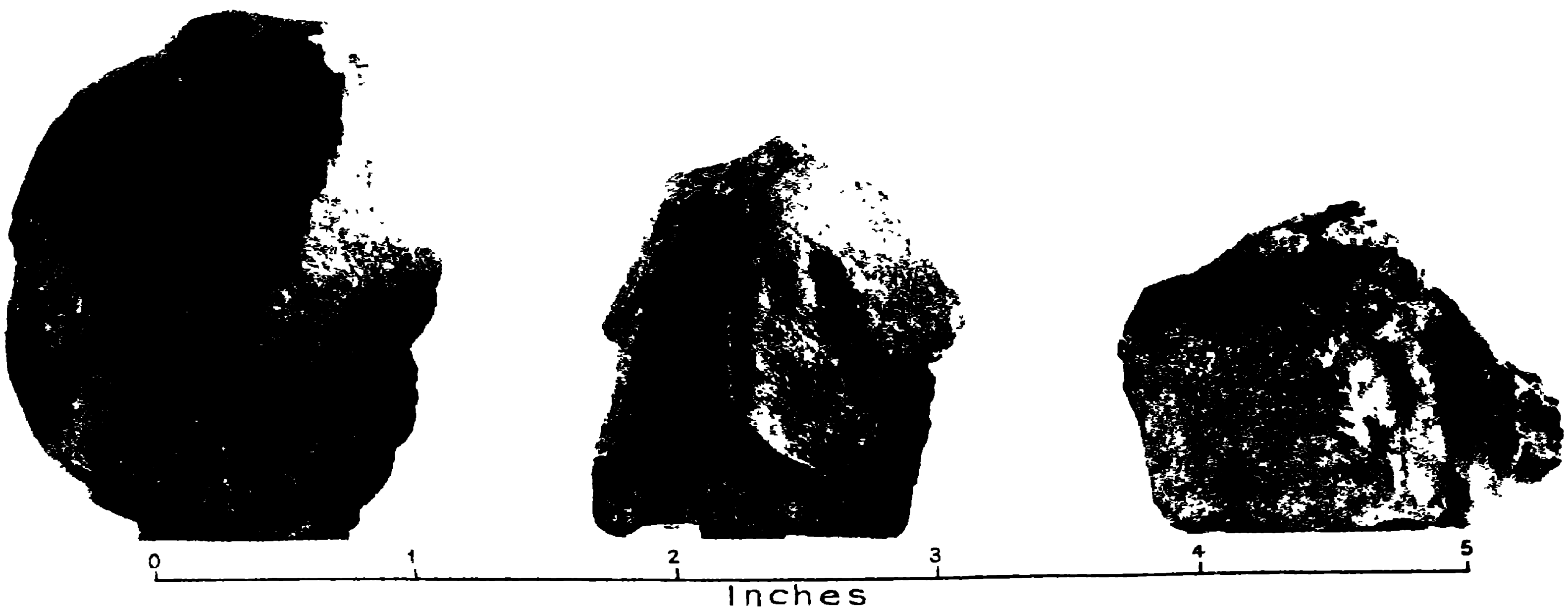
FIG. 1. PIECE II (KHANPUR), FRONT VIEW.

FIG. 2. PIECE II (KHANPUR), BACK VIEW.



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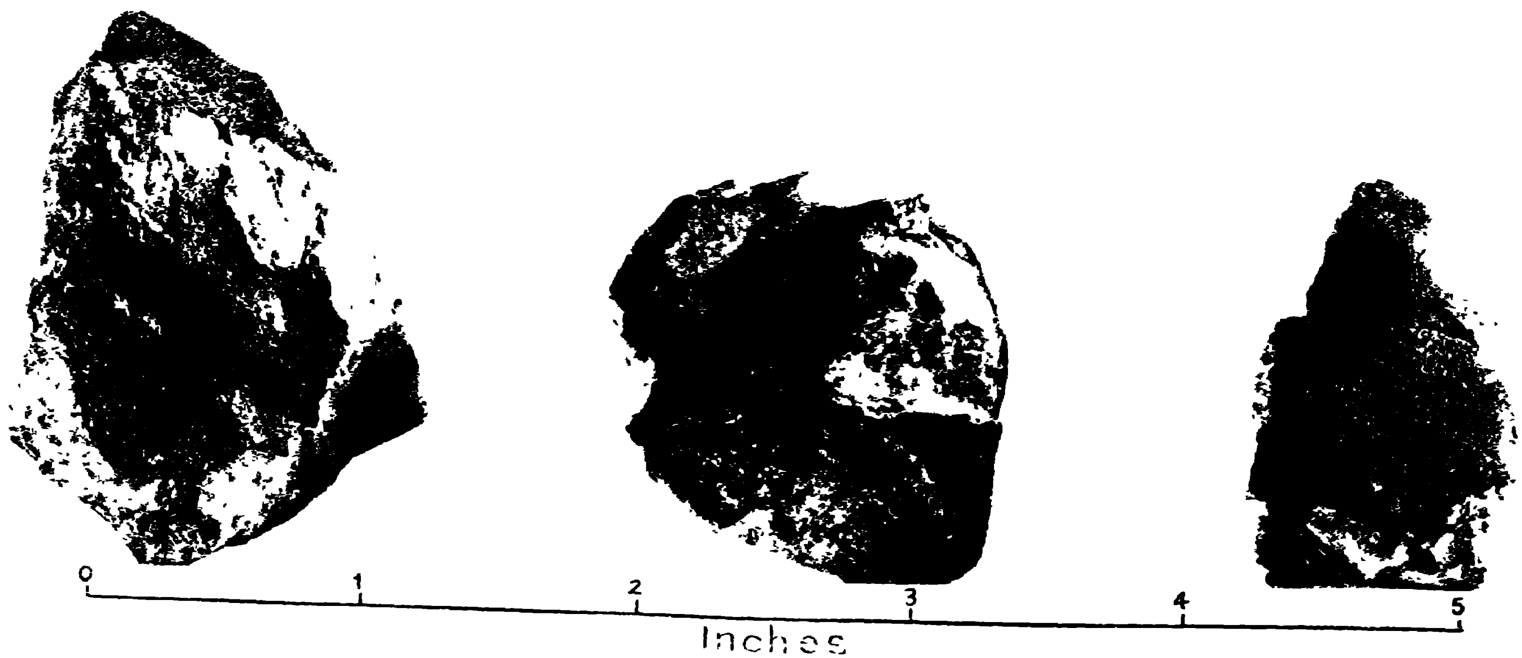
PIECE III (NEWADA), IV (GORKHA) AND V (ASMAN CHAK).

Records, Vol LXVIII, Pl 4.



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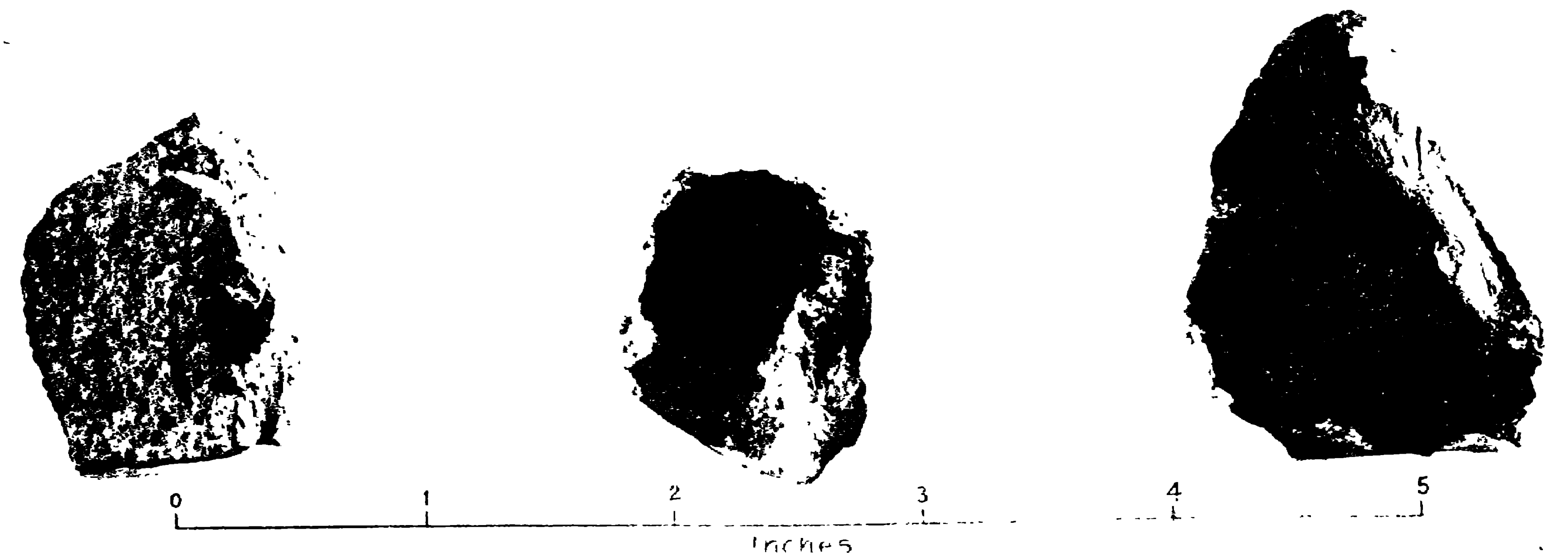
PIECES VI (AHLADPUR), VII AND VIII (GAURI).



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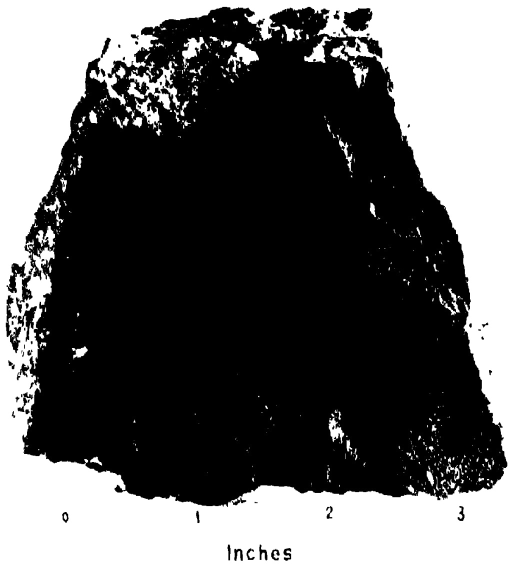
PIECES I (*b. c*) (GADANPUR), IX (MANDAI) AND XI (KARAULI).



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THREE VIEWS OF PIECE XII (KAKRAPAR), OBTAINED BY ROTATING IT SUCCESSIVELY THROUGH 120°
AROUND ITS VERTICAL AXIS.

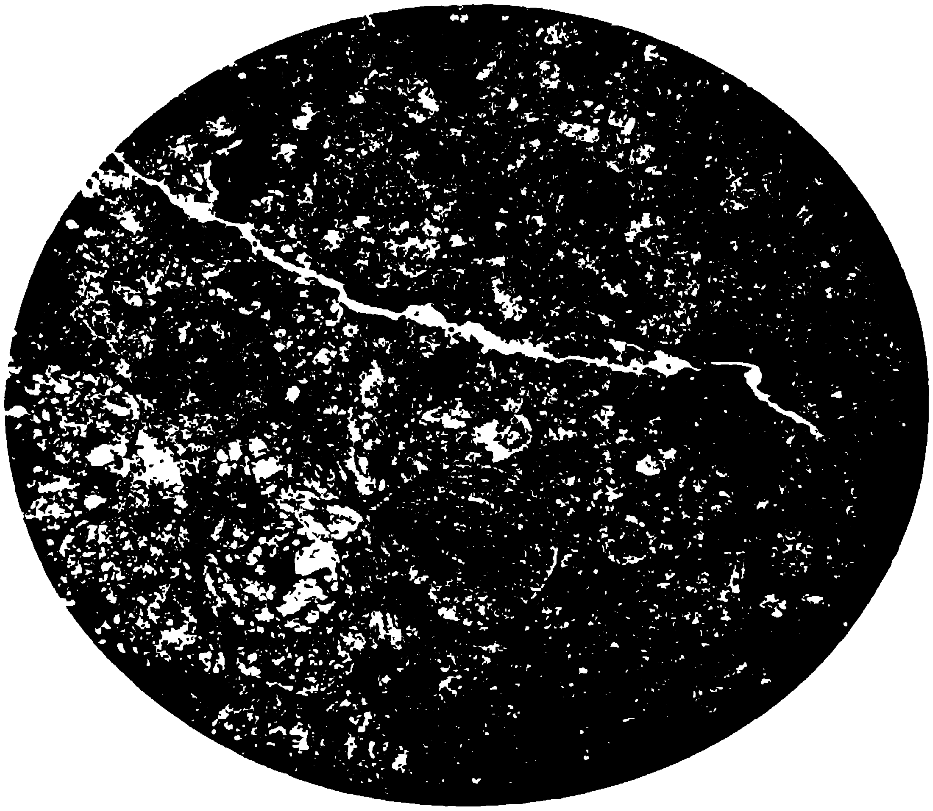
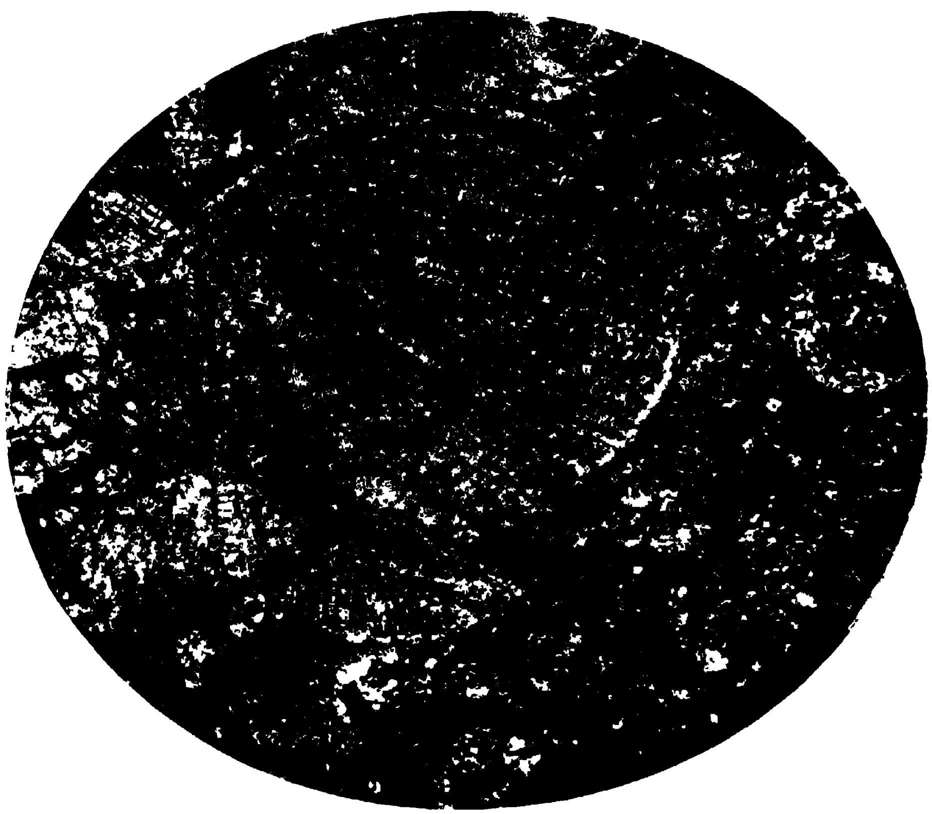
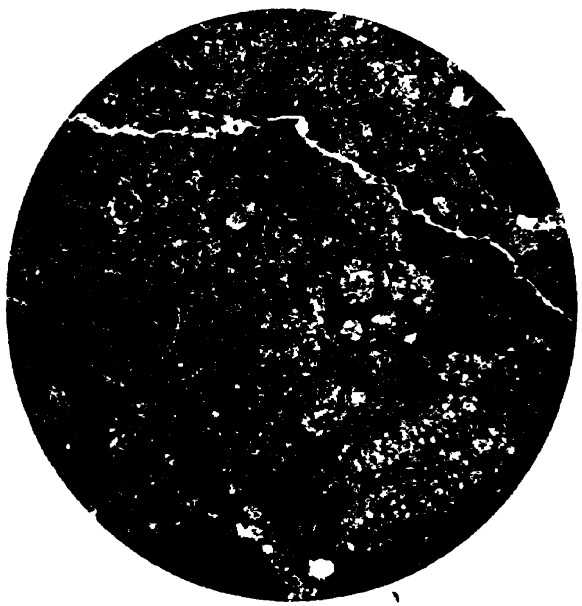


FIG. 1. SHOWING BRECCIATED APPEARANCE, RADIATING ENSTATITE CHONDRI AND GRANULAR OLIVINE CHONDRI. × 12.



M. S. Krishnan & P. L. Dutta, Photomicros *G. S. I., Calcutta.*

FIG. 2. AN ECCENTRIC RADIATING ENSTATITE CHONDRUS IN THE SAME SECTION. × 32.



M. S. Krishnan & P. L. Dutta, Photomicros.

FIG. 1. SHOWING AN EXCELLENT PORPHYRITIC OLIVINE CHONDRUS NEAR THE CENTRE. × 11.

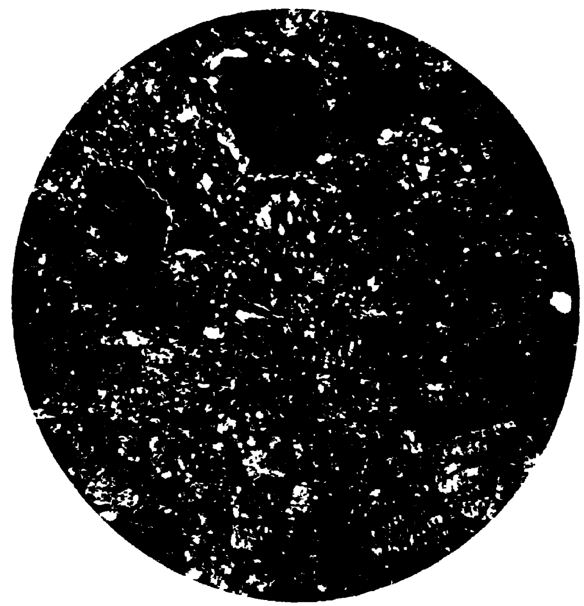


FIG. 2. SHOWING FINELY FIBROUS ENSTATITE CHONDRUS WITH PARALLEL ORIENTATION OF THE FIBRES. × 11.

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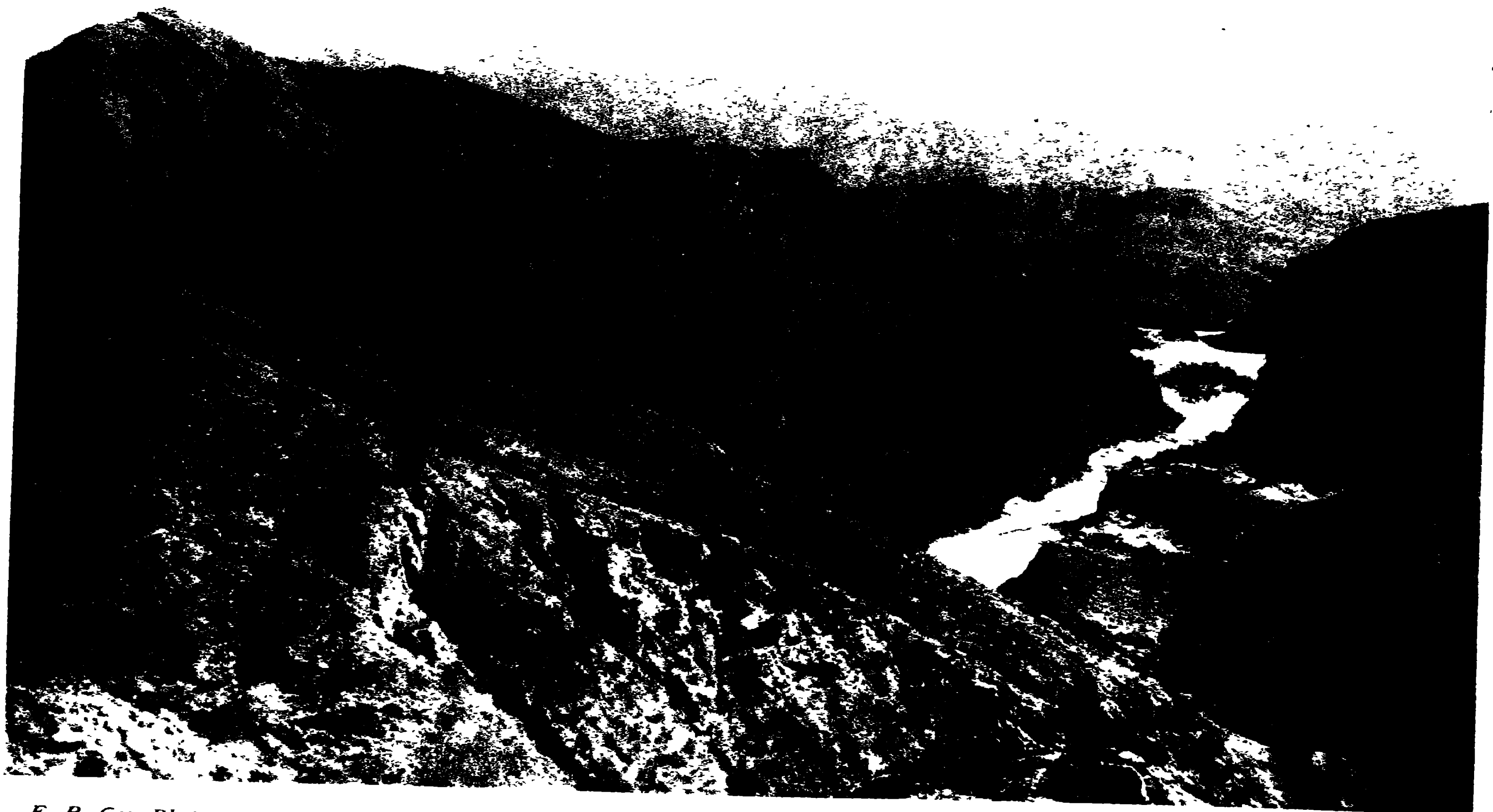
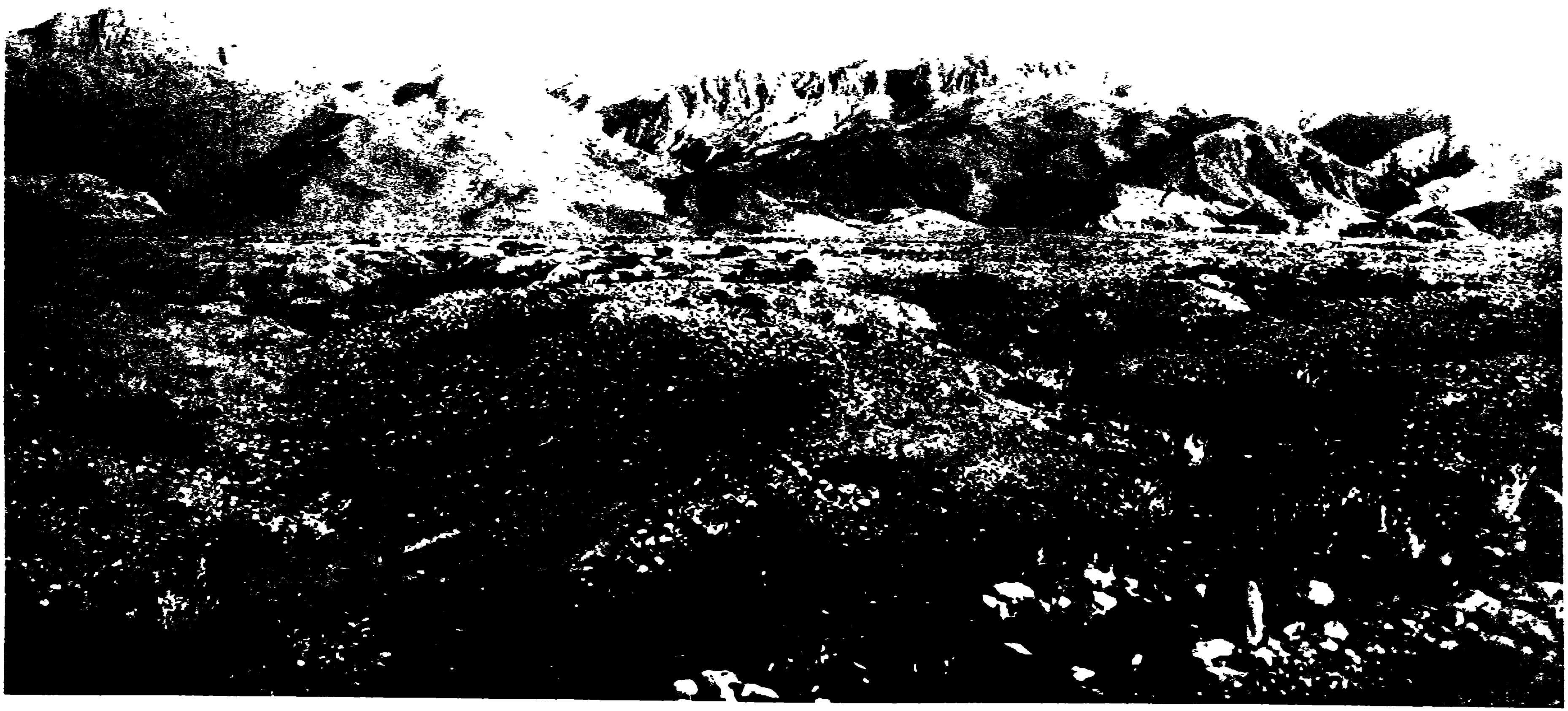
FIG. 3. SHOWING A RADIATING OLIVINE CHONDRUS. × 22.



E. R. Gee, Photo. G. S. I., Calcutta.

FOLDED CAMBRIAN BEDS FORMING THE RIGHT SLOPES OF THE DHODHA WAHAN, SALT RANGE.



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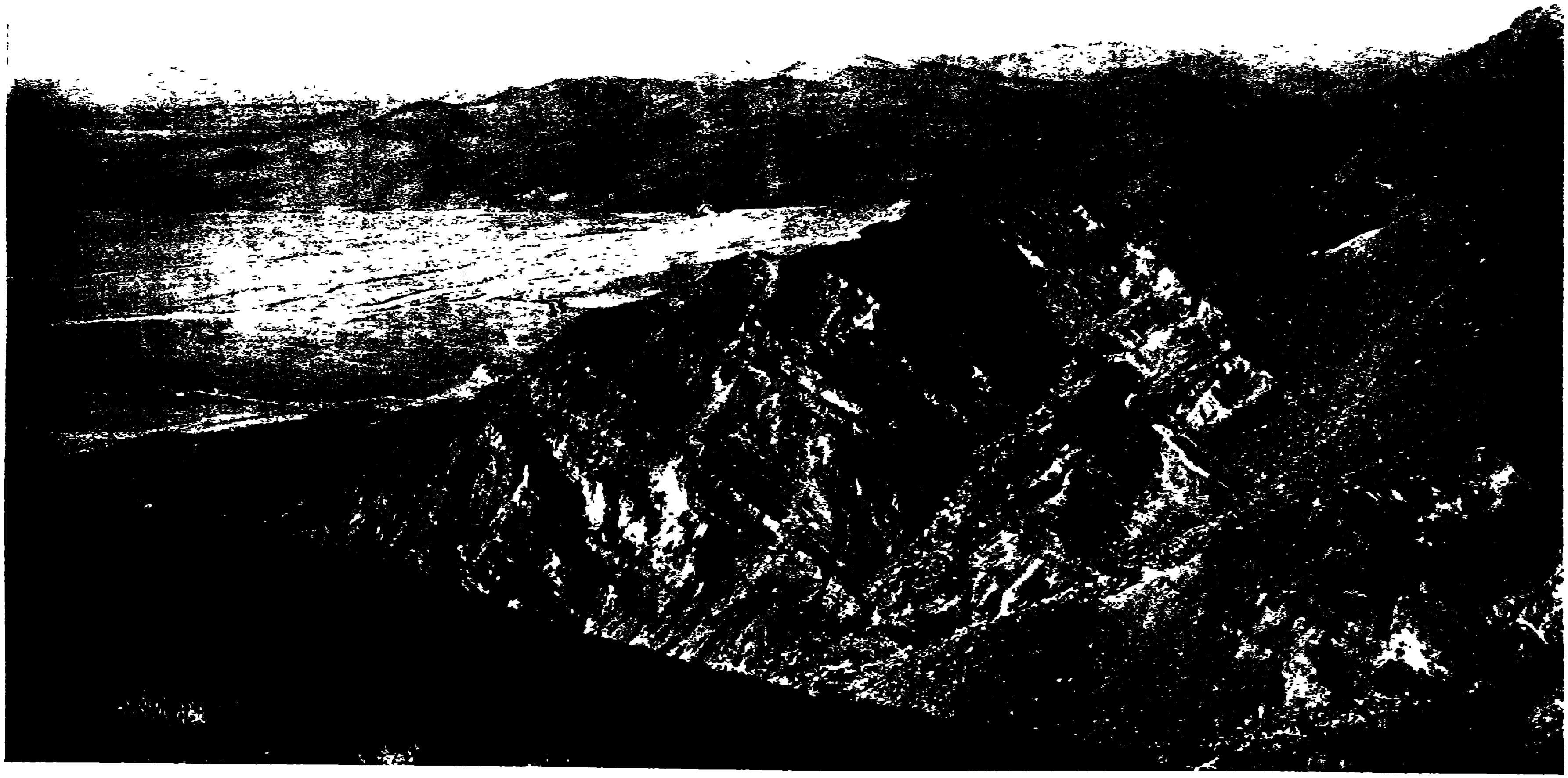
SCARP SLOPES SOUTH-EAST OF CHHIDRU. SALT RANGE.



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THE CAMBRIAN-TALCHIR BOULDER BED SEQUENCE SOUTH-EAST OF CHHIDRU, SALT RANGE.